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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 95, Number 1

January-March 1981

The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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Their Excellencies the Governor General and Mrs. Edward Schreyer

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

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The Canadian Field-Naturalist

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Second Class Mail Registration No. 0527 — Return Postage Guaranteed.

Back Numbers

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club*, 1879-1886, and *The Ottawa Naturalist*, 1887-1919, may be purchased from the Business Manager.

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Cover: Bighorn Sheep ram photographed by Luigi E. Morgantini on the Ya Ha Tinda Ranch, Alberta, during the winter of 1975–1976. See article on page 69.

THE CANADIAN FIELD-NATURALIST

Volume 95

1981

THE OTTAWA FIELD-NATURALISTS' CLUB

OTTAWA CANADA

The Canadian Field-Naturalist

Volume 95, Number 1 January-March 1981

The Ottawa Field Naturalists' Club Centennial Symposium 100 Years of Natural History in Canada

Introduction

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The late seventies have emerged as a time of retrospectives. There is widespread interest in "heritage" parks and buildings, historical exhibits, and retrospective collages of movies and television shows. There is no time more appropriate for a review of past achievements than at a centenary, and The Ottawa Field-Naturalists' Club, established 100 years ago, has not let the opportunity slip by.

In my opinion, a periodic stocktaking is a worthwhile exercise. It tells you not only where you have been and where you are, but, if done seriously and thoughtfully, perhaps where you are going or ought to be going as well. In this spirit, then, the Council of The Ottawa Field-Naturalists' Club decided to conduct a kind of colloquium, inviting experts in various fields to tell us what has happened in their own fields of specialization over the last 100 years or so. It was decided that the talks should have a Canada-wide rather than local focus to emphasize the role this club has played in the study of natural history throughout Canada.

The meeting took place on 19 May 1979, at the Victoria Memorial Museum (home of the National Museums of Natural Sciences and of Man). The papers, as you will see, related a fascinating history of natural history in Canada. It was clear from the outset that the history took shape as a result of individual personalities reacting to events of the time. In fact, what emerged was a mini-history of Canada, with its stories of the explorations for the transcontinental railways, isolated Hudson's Bay Company trading posts, and growth of the major Canadian cities. They traced the change from the strong influence of Europe and Europeans on early endeavors to the gradual growth of a body of competent Canadian professionals and amateurs. It was pointed out by several speakers that serious amateurs made many significant contributions throughout this period.

Throughout the talks, it became clear that much of the accumulating information on Canada's natural history was revealed in *The Canadian Field-Naturalist*. Members of The Ottawa Field-Naturalists' Club have every right to be proud of the part the journal has played in documenting the history and development of the field-oriented natural sciences in Canada.

The papers are presented here in the same order in which they were given at the May symposium. Only two of the papers are not included: the entertaining, informal presentation of *100 Years of natural history in Ottawa* given by William Dore, and *Canadian botany since Hooker (1840)* by Bernard Boivin which is not yet available for publication.

Editor's Note: These symposium papers retain the approaches and styles used by their authors in their oral presentations. Although not formally reviewed nor as rigorously edited as conventional scientific articles, they have nonetheless been checked for accuracy and clarity by specialists in the several disciplines.

200 Years of Ornithology in Canada[1]

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The topic, 200 years of ornithology in Canada, is a large one and in the time allotted, I can do no more than provide a few vignettes which reflect my personal biases on the topic. At the risk of offending both eastern and western Canadians, all my examples come from central Canada. At the outset I am going to cheat and stretch beyond the guidelines set by the symposium chairman. The reason for this is simple; the groundwork for Canadian ornithology was established in the 18th, not the 19th century, and therefore I will consider a time frame of slightly more than 200 years, rather than 100.

First, there is the **discovery phase** in which I consider the origins of Canadian ornithology. This is the period when virtually nothing comprehensive had been written about North American ornithology, nothing in fact until Wilson and Ord published their *American ornithology* in 1808. The most important figure in Canadian ornithology in this period was Andrew Graham, some of whose observations were quoted by Forster in 1772. Whatever writings in ornithology were available at that time came from Europe.

Second, in the 19th century there occurred what might be called the **inventory stage**. Tomes on North American ornithology were becoming available (for example, Audubon's *Birds of America* published in 1826), and much of the descriptive inventory phase of Canadian ornithology was carried out by visitors to Canada, who collected and recorded, and filled in details of distribution and taxonomy. Henry Hadfield, who visited Kingston in the 1850s, was one such visitor with whom I am familiar through the researches of Helen Quilliam in her delightful book, *History of the birds of Kingston, Ontario.*

The third trend in the late 19th and early 20th century could be called the **conservation phase**. Soon after Canadians became aware of the wildlife and birdlife present in the country, they became aware that in many species bird numbers were declining at a dangerous rate. Although population size estimates were nothing more than guesses, it was clear that species such as the Passenger Pigeon, the Eskimo Curlew, and the Golden Plover were fast approaching extinction. Contrary to what is normal at the present time, many of the conservation initiatives in early days were taken not at the prompting of naturalist and conservationist organizations but by alert and effective civil servants, many of them from Ottawa, men like James Macoun, Percy Taverner, Gordon Hewitt, and James Harkin. One such initiative resulted in the establishment of the Migratory Birds Convention Act in 1917. The book, *Working for wildlife*, by Janet Foster, is the source of many of the facts.

It was this Act of Parliament and the recognition that to understand and protect birds in this country it was necessary to know more details of the population dynamics and overall biology of birds, which led to the fourth stage of Canadian ornithology which could be called the **population studies phase**. This is characterized by a need to know how many individuals of a species exist and whether the species is increasing or decreasing. Much of the activity of ornithologists, both professional and amateur, at the present time is related to this —Christmas counts, breeding bird surveys, aerial censuses of colonial birds, bird-banding programs, and the like.

My first vignette, then, is of Andrew Graham, who, but for a mysterious act of plagiarism, would be much more widely recognized as the father of Canadian ornithology than he is. It is good to remind ourselves that much of our country was discovered and settled from the north, and an understanding of the avian inhabitants of the country's biomes, the taiga and the tundra, was in fact known earlier than that of more densely settled parts of the country. Andrew Graham was an employee of the Hudson's Bay Company and was sent over from Scotland as a young man in 1741 to work in the three major trading posts on the west coast of Hudson Bay. He was a trader at Fort Severn, second-in-command at Fort York, 1762–1774, and Chief Factor at Fort Prince of Wales (Churchill) from 1774 to 1775. He then returned to Scotland where he died in 1815. During his years on the bay, he traveled extensively between the forts, often carrying the packet, and he kept notes of his observations, not only on the birds, but on other wildlife, people of the region, and fort life. These observations are now preserved in 10 separate books in the Hudson's Bay Company archives in Winnipeg, all carefully handwritten. Each is slightly different as later copies were added to and subtracted from. Graham's style is quaint at times and some of his birds are difficult to recognize from his descriptions. One must remember, however, that he had no scientific training and no companions except Thomas Hutchins with whom to discuss

[1]This paper was presented on 19 May 1979 at The Ottawa Field-Naturalists' Club Centennial Symposium entitled *100 years of natural history in Canada.*

his ideas. He had to rely on European texts such as Pennant's *British zoology*, used only his eyes and his gun, and worked in an extremely inhospitable environment particularly in the winter months. Here is an example of his work, a description presumably of a Boreal Owl:

> Shipomosish, the small owl. This is the smallest owl in the Hudson's Bay, nearly corresponding to the Small Owl of Pennant. It weighs four ounces and a quarter. The length is eight inches and a half; the breadth twenty. Irides bright yellow; the feet and legs are feathered and talons black. There is no material difference between the cock and hen birds, only the latter being smallest, which is a distinguishing mark of the owl genus. It lives amongst the pines in all seasons feeding on mice. It builds a nest half way up the pine tree in the month of May; lays two white eggs, and the young fly in the month of July. They are not plenty, and are the most solitary bird in Hudson's Bay, seldom moving in the daytime, but a brisk mouser in the night. They never change colour. It is sport for the Indian children to steal towards them in the daytime and seize them.

The description does not rule out Saw-whet Owl but by location is almost certainly the Boreal Owl. There are some errors of fact such as the observation that female owls are smaller than males, but, on the whole, the report suggests the interest of an active naturalist who has a personal knowledge of the bird in the field. Graham sent many specimens to Europe and many of these became the type specimens upon which the original descriptions were based. Forster in 1772 described for the first time Great Gray Owl, White-crowned Sparrow, Blackpoll Warbler, and Boreal Chickadee on the basis of specimens sent to Europe by Graham.

The fifth copy of Graham's *Observations* in the Hudson's Bay Company archives is ascribed not to Graham but to Hutchins. Hutchins was a surgeon who spent 16 years on the Bay. It is clear from researches carried out by Glyndwr Williams that Hutchins took Graham's work to Britain and presented it as his own. Whether he did this with Graham's knowledge has not been finally resolved, but even in his later life Graham always referred to "my friend, Mr. Hutchins."

The major consequence of Hutchins' plagiarism was that Pennant's *Arctic zoology*, the major work of this time, published in 1785, refers to Hutchins for all of Graham's observations, and to this day the small arctic race of the Canada Goose is referred to as the Hutchins Goose, not the Graham Goose.

Let us now turn the clock forward almost 100 years. At this point a number of important treatises on North American birds had been produced. Visitors to Canada could uncover the local patterns of distribution and sort out the problems of classification. Graham was confused about various types of sparrow; these had been clarified in Hadfield's day. Hadfield visited a Canada already modified by the agricultural activities of man. Let us take a field trip with him in mid-19th century, as quoted in Helen Quilliam's book from Hadfield's 1859 paper in *The Zoologist*.

> Quitting the town of Kingston by the Upper Portsmouth road, leaving the Cathedral on the right and the splendid new Court-house on the left, you proceed for nearly a mile on the usual raised boarded foot-way, through level, half cultivated fields almost without a tree or even a stump, then leaving the high road, and striking off obliquely to the right for half a mile or more over a barren looking common, dotted here and there with clumps of everlasting fir, the first wood or enclosure is reached . . . there, being endless snake fences to be clambered over, no easy matter when encumbered by shot and gun, to say nothing of heavy boots . . . and ornithologists afflicted with obesity . . . should pause ere they trust themselves astride on the top most bars of suspicious looking snake fences, as they are in these old enclosures very apt to give way, when great is the fall thereof. I have in my mind's eye a vivid recollection of a scene of this sort, but the sufferer, fortunately, was of the leaner kind, or the fall of some five or six feet, gun in hand might have knocked out his own brains as well as those of the much prized specimens he held.

Birding in the 19th century could be a hazardous business, but less rugged than the life which Graham led, one feels. This rural scene is at the present day part of urban Kingston, as man continues to modify the environment. Scientific writing in Hadfield's day portrayed a more leisurely pace of life. What modern editor of *The Canadian Field-Naturalist* would tolerate Hadfield's rambling style?

It was through scientists and collectors like Hadfield that the basic knowledge of bird distribution in Canada was obtained, and it was from this base of knowledge that the concern for depleted wildlife resources arose. The depletions arose from three major sources: habitat destruction, market hunting, and the millinery trade. We are all familiar with the effects of habitat destruction particularly on woodland and marshland species. Market hunting is now a thing of the past and some of the species which were at that time threatened with extinction seem to be building up in numbers again now — species such as Hudsonian Godwits, Golden Plover, and Trumpeter Swans. Perhaps most remote from us at the present time are the depredations of the millinery trade. Janet Foster (1978) in her book *Working for wildlife* quotes a lady at the turn of the century as saying, "There is a great deal of sentiment wasted on birds. There are so many of them they will never be missed, any more than mosquitos. I shall put birds on my bonnet." Herons and brightly colored birds were the most vulnerable.

The problem was finally recognized and seen to require for its solution agreement at least between Canada and the United States. In addition agreement between the Dominion government and the provinces was

necessary. Dedicated civil servants sensitive to the issues were needed to guide legislation through all the potential hazards. Fortunately there were such dedicated men available. Gordon Hewitt as Dominion Entomologist was concerned with the economic value of birds and their importance to agriculture. He came to Canada from England and brought with him the European as opposed to North American wildlife tradition. He also had a potentially important political advantage in that his wife was the niece of Prime Minister Robert Borden. She wrote about her husband on one occasion as follows: "Morning and evening he walked around the garden, bathing himself in greenness, and in the odour of lilacs, roses and new mown grass. Then it was he spoke to every flower and bird, no matter how small or how shy, and held conversation with the chipmunks and squirrels, who held a safe tenure within the garden precincts."

Perhaps it needed devotion like this to put the Migratory Birds Convention Act on the statute books. The act has now been in place for 62 years and has had a major effect on Canadian ornithology.

This takes us to our final stage, which I call the **population phase**. If we have the legislation to protect and preserve migratory bird species, then we need to be able to monitor population changes, to detect population declines, and to understand population dynamics. We need the facts to know when and how the laws should be applied.

Much of the energy of the Canadian Wildlife Service (CWS) has gone into the acquisition of population data through their own research, through contracts with Canadian universities and others, and by encouraging amateurs. I will give a few examples of this from my own experience.

The Lesser Snow Goose population which nests in the Hudson Bay region migrates through the prairies to the Gulf Coast. As such it is vulnerable to hunting and destruction of its feeding areas. In 1972 CWS attempted to make a total count of the nesting geese in this population. Aerial photographs were taken during June when the birds nest in large colonies. Each colony was visited and photographed. Each individual nesting female appeared on the photograph as a white dot, and each dot was counted. This was an enormous undertaking but from this it was determined that more than one million Snow Geese were nesting in the Hudson Bay – Foxe Basin regions. This seems to be the only Canadian species other than the extremely rare ones such as the Whooping Crane, for which a reasonably accurate census is available. Such censuses are essential if population changes are to be assessed.

I have been involved as a university researcher in another aspect of the population monitoring (see Cooke and Sulzbach 1978). Since 1968 we have been studying closely a self-contained Snow Goose colony at La Pérouse Bay in northern Manitoba. By collecting data on an annual basis it is possible to assess annual mortality and annual production. These are necessary measurements if population declines are to be detected. Unfortunately this information is known for too few species of Canadian birds.

Most of the monitoring of population changes comes, however, not from the professional ornithologist, but from the amateur: the weekend birdwatchers and birdfeeder watchers. The documentation of the spread of the Cardinal into Ontario or of the Evening Grosbeak from the West depended largely on the observations of dedicated amateurs. Christmas bird counts if analyzed cautiously can be used to document changes of status of some of our birds. More recently breeding-bird surveys have been introduced which give a certain standardization to amateur record keeping. This is an early example of government initiatives in harnessing the activities of amateur birdwatchers.

The assistance which the Federal Government has recently given to Canada's two bird observatories, Long Point Bird Observatory and Prince Edward Point Observatory, points also to the importance of data collected systematically by amateurs. The increase in certain species of warblers at migration points in years of high Spruce Budworm outbreak has been reported. Most birdwatchers are happy to have their observations used for such a purpose, and the efforts of government agencies such as the Canadian Wildlife Service in coordinating the activities are welcomed.

There is much still to be done. Much of our inspiration still comes from Europe where more progress in this direction has been made. In *The Atlas of British birds* (1976) the distribution of every British breeding bird is recorded, and estimates of the numbers of each species plus indications of range expansions or declines are noted. Because of the geography of Canada and because we have fewer birdwatchers it will be several years before we can emulate the Atlas here, but there are beginnings. At the 1979 Ontario Ornithologists meeting, a small committee was set up to look into the feasibility of an atlas project at least for the settled parts of southern Ontario. I welcome these initiatives.

We have come a long way since the "Observations" of Andrew Graham. I am always overwhelmed, however, by how little we still know. The amateur birdwatcher can still find out new facts himself or become part of a team doing essential census work. Only by doing this can we ensure that the Migratory Birds Convention Act can be

effectively administered. Our hobby or research can be turned to good use for the protection of those species we enjoy observing.

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Mammalogy in Canada: a Historical Overview[1]

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Mammalogy is simply the study of mammals and is usually restricted to wild, nonhuman mammals, as I will do here. The story of the development of mammalogy in Canada is closely interwoven with the history of events and human beings in Europe and elsewhere in North America as well as in our own country. It is a complex and interesting story but far too long and varied to relate in the limited time available to me, so I'll tell you something of the background, some highlights, some interesting episodes, and something about interrelations of The Ottawa Field-Naturalists' Club and Canadian mammalogy over the past century.

Certainly only well within the last 100 years, perhaps only within the last 60, has mammalogy reached the state of being considered by its practitioners or by scientists in general as a separate field of science anywhere in the world, but especially in North America, which is in the forefront of mammalogy. Prior to the last six or seven decades most work in mammalogy was done on the side by ornithologists. The early work was often done rather casually and most early reports on Canadian mammals are either scattered through the journals of explorers, or are in combined bird–mammal publications, often as mere appendices to ornithological reports.

Discovery Phase

To outline the saga of the evolution of mammalogy in Canada, I must go back much earlier and set the scene by dealing with other parts of the world first. I am going to have to wander quite a bit outside Canada because external cultural and political events have had a great deal to do with Canadian mammalogy.

Certainly all aboriginal peoples who depended on animals for food and clothing knew something about mammals. This knowledge was essential to their survival. They had practical, often ecological, information which was passed down from generation to generation usually by the spoken word, although graphics were sometimes employed. Written reports came much later and at first were based more on superstition, on rumors, on speculation, than on observation. If you'd like a time reference, I'm talking now about the time of the ancient Greeks, around 2000 years ago. I'll take a big jump over the Dark Ages during which very little advance was made anywhere on incipient mammalogy.

The 15th and 16th centuries brought the beginnings of the major voyages of exploration by Europeans to the New World, but aside from relatively minor mentions of mammals by adventurers, there was no significant documentation of New World mammals. In the 17th and 18th centuries exploration intensified and colonization of different parts of the world became significant. Back in Europe there were many wealthy people with a great deal of leisure time that could be devoted in part to cultural activities. Many developed an interest in natural history, and amassing specimens as display objects for their natural history cabinets was one of the favored occupations of many gentlemen. (I'm sorry to state that I'll have to report exclusively about the activities of gentlemen rather than ladies in this context; I don't know what the ladies' interests in natural history were in this period — perhaps botany and ornithology — because they've been little publicized.) Many of the European gentry interested in possessing and displaying specimens did not collect them themselves, but sent naturalist-collectors off to the New World, Africa, and elsewhere to explore and bring back new and interesting specimens for their private collections and eventually for those of the great institutions in European capitals. As a result of expanding exploration, commercial enterprises were set up to exploit the newly discovered natural resources of the colonies, and settlement commenced or accelerated. The major result of significance here is that there was a flow of specimens of mammals and other organisms back to Europe. Meanwhile, in several European countries, events occurred that collectively improved the scientific climate for the reception of these specimens. The organization of the Royal Society in London in 1662 greatly accelerated the acquisition of knowledge. A landmark date is 1758 when the 10th edition of *Systema naturae* was published by Karl von Linné (Carolus Linnaeus). This famous Swedish biologist initiated the system of scientific binomial nomenclature that is the basis for the scientific names we use today for all plants and animals. He named and described 86 species of

[1]This paper was presented on 19 May 1979 at The Ottawa Field-Naturalists' Club Centennial Symposium entitled *100 years of natural history in Canada*.

mammals in 1758 and others began to use his scheme to name still more species. Thus there was considerable activity in naming new species from specimens brought back to museums in London, Paris, Berlin, Munich, and other European centers. Sometimes, unfortunately, other new species were named only from descriptions or illustrations by earlier writers.

Concurrently there was awakening interest in paleontology in Europe largely as a result of the spark by Georges Cuvier in France in the late 1700s and early 1800s. At this same time, surprisingly, there was much activity in vertebrate paleontology in the fledgling United States of America. This was due largely to an eminent naturalist who wrote on fossils and other branches of sciences — none other than the third President of the United States, Thomas Jefferson. He and later presidents sent parties of explorers and naturalists into the western part of North America to survey the animals, plants, fossils, and minerals. For example, most have heard of the expeditions of Lewis and Clark, for whom Lewis' Woodpecker and Clark's Nutcracker were named. Very quickly there built up in the United States a great tradition of semimilitary explorers and naturalists. Sometimes the same person filled both these roles; sometimes the surgeon who went along was also the naturalist. There were many of these expeditions in the first half of the 19th century and they intensified in the 1850s when a route was sought for a railroad to the Pacific. They all brought data and specimens back east to new museums that were founded by individuals, universities, and governments at several levels. Clearly this was a continuation of what had gone on earlier, when the specimens went to Europe. During the latter half of the 19th century, the museums of the United States built up staffs of specialists who studied all this western material; in particular they described many new species, including new mammals. There was rapid publication and efficient dissemination of knowledge. Here was the case of aggressive and productive United States enterprise! In case you wonder what significance this has for Canada, it is that these expeditions were not confined to the western states, but they entered Mexico, and they went a great deal into British North America. Thus, again foreigners were collecting, removing, and describing part of Canada's natural resources! I'll now come closer to home briefly and quote from the President's Address to The Ottawa-Field Naturalists' Club in 1887. John Macoun (Ottawa Naturalist 1(2): 20. 1887) was deploring, as so many have since, the indifference of Canadians in contrast to all this aggressive activity south of the border. He deplored also the lack of a great museum in Canada and said, "It is painful to confess that all our best specimens, whether mineral, animal, or archaeological are going to Washington, and the apathy of our people is such that I see no help for it." I'll refer to a later stage of this removal of part of our heritage shortly.

No account of mammalogy in Canada is complete without saying something about the fur trade, which was based, initially at least, on one species of mammal, good old *Castor canadensis*, our friend the Beaver! This industry began in the mid-16th century as French explorers along the Atlantic Coast and up the St. Lawrence River began bartering with the Indians. Other Europeans, largely from the United Kingdom, also began exploiting this resource, for the fur of Beavers was very popular back home. In 1670 Charles II granted a charter to the Hudson's Bay Company to utilize the Hudson Bay area. From that date until Canada was ceded to Britain in 1763, there was intense competition between the French fur traders based at Montreal and the British traders with Hudson Bay as their center of operations. As the populations of Beavers were depleted, trapping activities and the establishment of trading posts were gradually extended westward, and this led to further exploration and eventually to settlement. Various species of mammals other than Beavers and other valuable furbearers were also obtained by the fur traders and sent back to Europe. The process I described earlier of these specimens being described and named by European scientists who had never seen the living or intact dead animal took place in Britain, France, and Germany. For instance, J.R. Forster was asked by the Royal Society in the 1760s to examine "a choice collection of skins of quadrupeds . . ." collected by servants of the Hudson's Bay Company at their posts on the bay.

There was sometimes a very anomalous consequence of scientists obtaining specimens from nonscientific sources such as the Hudson's Bay Company and its competitors. Some of you students and scientists know that I frequently complain about inadequate data on specimen labels. Well, the data accompanying specimens from the fur-trading companies were certainly minimal, if they existed at all, and usually consisted of only the names of the posts from which they had been shipped. When a species new to science is being described and named, the author records the "type locality" as the locality from which the holotype or "type specimen" came. Needless to say, the type localities of some Canadian mammals described in the 18th century by Europeans from specimens obtained from the fur trade are rather vague and sometimes even outside the natural range of the animals! One example is *Taxidea taxus*, the American Badger, which in Canada occupies grassland regions of the prairie provinces, some valleys in British Columbia, and a couple of specific parts of western and southwestern Ontario. It also extends, of course, extensively through the western United States and northern Mexico. Its type locality,

though, is "Labrador and Hudson Bay" as recorded by the German Schreber, who described it in 1778. He cannot be faulted because he did not know any better, not having been to North America, and not knowing that American Badgers are prairie-dwellers that have never been recorded in Labrador nor anywhere near Hudson Bay. I presume that although his specimen must have truly been shipped from a fur post on the shore of Hudson Bay, it had actually been killed somewhere in the prairies by Plains Indians who traded it to Swampy Crees or Chipewyans who transported it up the Nelson or Churchill rivers to a post on the bay. We'll never know for sure. That is just one example; there are comparable ones.

Before leaving the fur trade, I should mention that our knowledge of the natural history of northern Canada began with the formation of the Hudson's Bay Company in 1670. Several of the men sent from Britain as factors in charge of trading posts were keen naturalists and sent reports of their observations and specimens of mammals, as well as of birds, etc., back to the United Kingdom. Some well-known explorers of northern Canada who were associated with the fur trade also recorded observations on mammals. For example, Alexander Mackenzie in 1789 described the "white buffalo" in the mountains of the northwest. His "white buffalos" are now known as Mountain Goats. In 1796, Samuel Hearne published rather accurate (for his time) observations on northern mammals that had seen on his travels between 1769 and 1772. Incidentally, the old records of the fur trade proved to be important to 20th century mammal ecologists such as Elton, Chitty, and MacLulich, because they provided data on population fluctuations of foxes, lemmings, and hares over many years.

To finish off my consideration of this discovery or exploration phase of Canadian mammalogy, let me remind you that our knowledge of the fauna of arctic Canada was greatly increased during an era of exploration stimulated in 1818 by the British government's offer of £20 000 for making the Northwest Passage from the Atlantic to the Pacific. Three British explorers who were prominent in this search were Sir John Franklin; Sir John Richardson, who was surgeon–naturalist for Franklin's expeditions of 1819–1822 and 1825–1826; and Sir William Edward Parry. They were most active in the decade after 1819, but Richardson was active until 1848. His last trips were to hunt for the ill-fated third Franklin expedition of 1843. One special item of interest to mammalogists is that all three of these gentlemen have been commemorated by having species of ground squirrels named after them! So we have Franklin's (*Spermophilus franklinii*), Richardson's (*S. richardsonii*), and Parry's (now Arctic) (*S. parryii*) Ground Squirrels. I don't know if they'd be honored; I hope they would; I certainly would! Of these three men, Richardson contributed by far the most to natural science by describing mammals (and other animals) he saw and collected on his travels. The first part of his *Fauna boreali-americana*, published in Britain in 1829, was a real landmark in describing the quadrupeds of northern Canada. His collections, like those of many others, including type specimens, went to the British Museum in London.

At the close of the active period of arctic exploration by the British coincidental with the discontinuation of the search for Franklin's expedition about 1857, the involvement of the British with Canadian natural history including mammalogy became almost nonexistent. United States zoologists replaced the British as outside investigators of the taxonomy and distribution of Canadian animals through their expeditions, identification of submitted specimens, and taxonomic studies. Otherwise, contributions were largely being made by workers whose primary responsibilities were in other activities, and whose interest in mammals was personal rather than official. Thus during the rest of the 19th century, there were various minor accounts of Canadian mammals by explorers, geologists, missionaries, and others including a few naturalists, all adding bits and pieces of information, but there would not be a Canadian medium for pulling them all together for some years.

Before proceeding to a completely different aspect of the story, I should report on the increase in numbers of mammals known. In 1820 Desmarest described all known species of North American mammals — about one hundred. The first list of Canadian mammals was published by a member of The Ottawa Field-Naturalists' Club, J.B. Tyrrell, field-geologist of the Geological and Natural History Survey of Canada, in 1888. His 28-page *The Mammalia of Canada* listed 123 species with brief annotations. Frank Banfield's *The mammals of Canada* published in 1974 treated 196 species.

Contributions by Canadians in the 19th Century

I shall digress now to tell you about the nature of contributions to mammalogy by Canadians during the 19th century, and especially, around 100 years ago, the latter in response to a request by the chairman of this symposium. Among the earliest writings about Canadian mammals by Canadians, and including perhaps the first records of Ottawa-area mammals, are general accounts of cervids ("Moose Deer," "Wapite[sic] or Canadian Stag," "Common Deer"), carnivores (bears, foxes, skunk), and squirrels published in 1856. They were all written by Elkanah Billings, amateur paleontologist, naturalist, barrister, former Editor of *The Citizen*,

publisher, and from 1856 to 1876, the first paleontologist to the Geological Survey of Canada. He published his mammal articles in the first volume of *The Canadian Naturalist and Geologist* which he founded in Ottawa (and of which he was at first practically the sole contributor), but he moved it to Montreal later in 1856. This was, I believe, the first English language natural history serial in Canada, and its publication ". . . marks an epoch in the history of the progress of scientific research and discussion in Canada" according to President H.M. Ami in an address to The Ottawa Field-Naturalists' Club in 1900 (Ottawa Naturalist 14(11): 204. 1901).

My search for information next led me to the first few volumes of the publications of The Ottawa Field-Naturalists' Club. In perusing them, I was quickly captivated by the amount of fascinating information and the literate, readable style, so that I could hardly put them down. Although there is plenty about plants, plenty about birds, plenty about insects, plenty about fossils, and even plenty about the common local mammal *Homo sapiens*, in contrast there is precious little about native Canadian mammals. In *Transactions of The Ottawa Field-Naturalists' Club* No. 1 for 1879–1880, aside from humans, there is absolutely nothing about mammals. In *Transactions* No. 2 the next year, John Macoun mentioned that buffalo and deer had ". . . eaten the district [of the prairies] bare," but that's the entire content about mammals. In *Transactions* No. 3 and 4, I could find nothing about Canadian mammals, but lots about geology, plants, insects, birds, and shells, for there were then highly organized "branches" of the club studying these groups.

In *Transactions* No. 5 for 1883–1884, in H. Beaumont Small's President's Inaugural Address, which was delivered 6 December 1883, he referred to certain accomplishments of the club over its four years of existence in publishing much local information on geology, stratigraphy, minerals, plants, birds, fishes, and shells — listing, then adding to and perfecting their lists. Indeed this was in accord with the "object" of the club to study "the natural history of this locality." But he went on to predict that ". . . before another four years shall have passed, the resources of this district will be so thoroughly known that we shall be sighing for fresh fields to explore and conquer." He was contemplating expanding the club's efforts to surrounding regions of the country before even one word had been written about a local mammal. How shocking! In that same address, however, Small did acknowledge that mammals existed. The first use of the work "mammal" in the club's publications was in his profound statement "Mammal orders are according to the hoof and teeth, . . ." [sic]. In the ensuing discussion Macoun mentioned "marsupials and monotremes, the lowest forms of mammalia [sic]" but this was strictly out of the book because the former were not then known to occur in Canada and the latter are not known to range outside Australasia. Finally, late in this same volume, appeared the very first paper on mammals in the club's publications. "The deer of the Ottawa Valley" had been delivered on 13 March 1884 by W.P. Lett. It dealt with Moose, Caribou, Wapiti, Virginia or Red Deer [now White-tailed Deer], and was rather well done. Towards the end of *Transactions* No. 5, in the first Report of the new Zoölogical Branch of the club, was the first note on small rodents. I was pleased to learn that they finally recognized the existence of some of the wonderful beasts I study — "white-footed or deer-mouse," as well as the "meadow mouse" and "jumping mice" (*Zapus hudsonius*), which they seem to have called also "kangaroo mouse."

Transactions No. 6 for 1884–1885 contains the President's Inaugural Address again delivered by H. Beaumont Small, M.D., on 4 December 1884. He referred to what had been accomplished by the club and what remained "for new workers to begin upon." This perceptive naturalist now realized that mammals had received very little attention, and he promoted "the systematic study of our mammals and the preparation of a perfect list" with annotations. The only paper on mammals was "The Canadian Otter" by William Pittman Lett. The Report of the Zoological Branch by Small and Lett contained almost two pages on local mammals including the first mentions in club publications of bats and two reports of seals in the Ottawa River. They hoped to present "a complete list of the mammals met with in this vicinity" the next year but this hope was not realized until 1945, when A.L. Rand's "Mammals of the Ottawa District" appeared in *The Canadian Field-Naturalist* (59: 111-132). Indeed the momentum of the previous number did not carry over to *Transactions* No. 7 for 1885–1886, for the only significant article on mammals was "The Black Bear" by none other than William Pittman Lett. This man was still the only club member to put his own observations and others' published observations on mammals together into species accounts, and he did it well too!

In 1887–1888 *The Ottawa Naturalist* commenced as Volume 3 of the *Transactions*. At this time President John Macoun was in a complaining mood. He deplored the fact that contemporary Canadian naturalists didn't like to walk for miles in the countryside as many English naturalists did; instead they liked to ride to a point in the country, eat a hearty lunch, take a short stroll, eat again, then ride back to their homes. He also deplored the lack of botanic gardens and museums, and I quoted earlier his regrets that all the specimens were going to Washington and that people were so apathetic about it. He complained further that space was limited in the Geological Survey Museum in Ottawa. There was one small room for mammals and birds [we can't escape from

birds!], and the insects and plants were out in the hall! In other words, he advanced some of the perennial complaints that many of us in the museum community are still voicing. That same year, 1887, the club's faithful lone mammalogist William Pittman Lett reported on "The Cougar or Panther."

In the next President's Address in December 1887 R. B. Whyte stated, "We have pretty well accomplished our task of investigating and recording the results; the small additions that have been made to our lists of late years show that not much remains to be done . . . ." But he did realize that "next to nothing is known . . ." about the mammals, "making it a fertile field for study and investigation." Furthermore, without giving any details, he claimed that "every year our animals are becoming scarcer, and papers on the mammals . . . of the district would be interesting and valuable." Well, it took a long time before more than a few people did anything about the mammals of the Ottawa area.

On 9 February 1888, however, during the discussion after Professor Macoun's lecture on vertebrates, including mammals, came the first exhibition to the club of a mammal specimen (although whether it was actually prepared as a specimen for retention or merely exhibited as a carcass and later discarded is not stated). "Mr. [W. H.] Harrington exhibited a fine specimen of *Hesperomys* [now *Peromyscus*] *leucopus*, the white-footed mouse, which he had trapped the previous night in his shed. Attention was called to the great beauty of this native field mouse and a few remarks were made on its habits. The President, Mr. R. B. Whyte, urged the collection and study of our small mammals, of which there are many species but little known to the members" (Ottawa Naturalist 1: 179. 1888).

Shortly afterwards, on 1 March 1888, J. Ballantyne broke W. P. Lett's monopoly on presenting papers on mammals, for he read a paper on "Our Squirrels" at a soirée, and exhibited mounted specimens (from the museum of the Geological and Natural History Survey of Canada) of the different species (Ottawa Naturalist 2(1): 7. 1888) His paper, published on pages 33 - 44 of this volume, contains many personal observations of his own, plus information from the literature, about five local species. The remainder of Volume 2 of *The Ottawa Naturalist* contains only few brief mentions of mammals.

Volume 3 of *The Ottawa Naturalist* for 1889–1890, the last early volume I surveyed, contained some innovations, as well as the second-last contribution by William Pittman Lett, this time on "The American Skunk." The scope of the journal was extended to include papers from elsewhere in Canada instead of being confined to papers on purely local topics. Editor James Fletcher forthwith published a brief notice of the publication by C. Hart Merriam (from Washington) in an 1888 *American Naturalist* of the description of what was then considered a new species of red-backed vole, *Evotomys dawsoni*, whose type specimen had been collected in the Yukon by George M. Dawson, a prominent geologist and club member. This specimen, and others collected in southern British Columbia by John Macoun and his son and mentioned in this same volume, are the first bona fide museum specimens of mammals referred to in the journal, beyond the mounted squirrels mentioned earlier.

Anyone who has looked through these early journals knows that there are many accounts of the field trips of The Ottawa Field-Naturalists' Club. There are details on the plants, birds, insects, shells, and fossils found, but up to 1890, at which point I stopped my survey, there was only a single mention of a mammal being observed on a club outing. Even that observation, of a Red Squirrel "near Meech's [sic] Lake," was not in a formal account of an outing but was buried in Ballantyne's paper on squirrels (Ottawa Naturalist 2: 38. 1888). Well, I suppose this is not surprising; in contrast to birds, insects, and plants, most mammals, especially small ones — shrews, moles, mice, voles — are nocturnal, shy, secretive, and they're rarely seen. In those days, the little furry creatures in which I'm so interested were usually brought in by cats or dogs or they were picked out of water pails or rain barrels into which they had fallen, and usually they were in rather bad condition. Those that were actively collected had to be caught by hand, shot, or taken in steel traps. Only a few ingenious people seem to have devised traps to capture small mammals, at least in North America. One such person from the USA is the Reverend John Bachman, who, with John James Audubon, wrote the three-volume folio *The viviparous quadrupeds of North America* which appeared between 1845 and 1848. This was a landmark, the first major work on North American mammals. Bachman used a figure-4 trigger and an inverted bowl to trap mice.

Mousetraps and the Inventory Phase

This brief digression on relatively crude traps leads me to a story about how a brilliant but simple technological advance triggered a revolution in mammalogy. One of the conventional features of historical accounts such as mine is to describe the major "revolutions," "break-thoughs," or "turning-points" in the branch of science or technology being treated — Newton, Watt, Darwin, transistors, sputniks, lunar landings, and so on. Well, the new device that resulted in the first breakthrough in mammalogy was not nearly as spectacular as

these, but it was nonetheless important. The quantum leap forward in mammalogy came about as a result of the invention, mass production, and marketing of small, cheap, efficient, breakback mousetraps! Although this familiar device doesn't seem to rate in the earth-shattering category, this little product of Yankee ingenuity, first called the Cyclone trap when it was marketed in 1887 or 1888 — I'm not sure of the exact year — brought about a great revolution in mammalogy when its possibilities were recognized by a fertile mind.

To continue this story I must talk about a very important individual whom I have already mentioned in passing — C. Hart Merriam from the USA. This eminent pioneer mammalogist was elected a corresponding member of The Ottawa Field-Naturalists' Club in 1884 or 1885, and his donation of his book *Mammals of the Adirondacks* was the basis for the first published report of a publication on mammals being received by the club's library (Transactions No. 6: 159. 1885). He was a medical doctor whose interests lay more in ornithology and mammalogy than in medicine. He was employed by the United States Department of Agriculture in 1885 as the first Director of its Branch of Economic Ornithology in the Division of Entomology. The next year he expanded his branch to include mammalogy. Soon, with the advent of Cyclone traps, he envisaged a continental campaign of large-scale mammal-collecting; this was the complete revolutionary idea. He had realized that because animals range according to physiographic or environmental boundaries rather than political ones, comparative study of the systematics of North American mammals (and other organisms) required specimens from the entire continent. Accordingly he sent collectors throughout North America, from Mexico to arctic Canada. Their mission was to collect large series of small-mammal specimens, each with its own label bearing complete data — precise locality, date, collector's name, standard measurements, mass, sex, breeding condition, habitat, remarks, everything! These series of specimens showed both individual and population variation; they showed variation due to age, to sex, to season, and perhaps most striking of all, to geographic variation. Up to this period many museum collectors were content to obtain specimens of one male and one female of each species, hence this so-called "Merriam concept" of collecting many specimens was really very trend-setting and led to great advances in North American mammalogy. His collectors sent or brought their specimens and detailed field notes back to Washington, of course, and Merriam identified them. His many descriptions of new species and subspecies were based on these series rather than merely on single specimens, as was the usual case earlier. Merriam was a prodigious worker and he and his colleagues — Bailey, Preble, Nelson, Osgood, et al. — put out vast numbers of papers on mammals and other vertebrates collected on U.S.-sponsored expeditions or sent to Washington by other collectors. The findings of these early workers on the taxonomy and evolution of mammals have generally stood up very well in the face of more recent studies using modern techniques of electrophoresis, chromatography, karyology, and so on. As might be expected, many of their results were published in U.S. Government series such as *North American fauna* (from 1889) and in various publications of United States museums.

All this activity below the border has had one very striking consequence for Canada. I have already described how early mammal-collecting by Europeans resulted in the accumulation of specimens of Canadian origin in European museums. Then in the 19th and early 20th centuries, many Canadian specimens went to the United States. The result is that most holotypes from Canadian type localities are in museums in these other countries. Some types are not known, others have been lost, but many are in museums in London [see A. W. F. Banfield's 1961 paper in National Museum of Canada Bulletin 172 about some of our Canadian treasures in the British Museum (Natural History) there], in Washington, New York, Chicago, Ann Arbor (Michigan), Cambridge (Massachusetts), Munich, etc. Even though many North American species have type localities in Canada, our national collection of mammals in the National Museum of Natural Sciences in Ottawa contains not one single holotype of a Canadian mammal species. There *are* some holotypes of geographic races or subspecies there, but these are of much less importance and interest to most workers.

Canadian Mammal Collections

I have emphasized the large-scale collecting by personnel from United States institutions. Meanwhile, were there no Canadians also collecting specimens of mammals? Yes, there were. We too had our share of hardy explorers, missionaries, geologists, and naturalists traveling in the hinterlands of the west and north, especially during the latter half of the 19th century. Unfortunately many of the mammal specimens they collected were sent to the big museums in Washington or New York, and relatively few were deposited in the humble museum of the Geological and Natural History Survey in Ottawa or elsewhere in Canada.

Eventually though, the Merriam type of museum collecting began to be practiced by Canadians, and Canadian mammal collections were established. Unfortunately, however, the discovery and inventory phases had been so nearly completed — virtually all the species and almost all the subspecies had been described by

foreigners — that there remained largely the filling in of details, as far as taxonomy and distribution of Canadian mammals were concerned.

Nevertheless, through the efforts of devoted curators, technicians, and collectors, often working with extremely limited resources, valuable collections of mammals have been built up in national and provincial museums and in some universities across Canada. These collections serve not only as secure repositories for important specimens, which are part of our national heritage, but as reference collections or "bureaus of standards" for aid in identifying new specimens. The museums provide a place for researchers, whether professionals, students, or amateurs, to work with the valuable resources they hold, and some have scientific publication series for disseminating the new systematic and distributional knowledge emanating from their researches. The most important museum series of publications are those of the National Museum of Canada, the Royal Ontario Museum, and the British Columbia Provincial Museum. The development of museum collections of mammals, particularly those in universities, has advanced the development of mammalogy as an academic subject. Thus mammalogy in Canada has been positively influenced by the increase in number and quality of Canadian museum collections of mammals.

The latest information I have on the size and status of Canadian collections of mammals relative to those elsewhere in North America was collected in 1973 and published in 1975 by J. R. Choate and H. H. Genoways (Journal of Mammalogy 56(2): 452–502). There were then in eight provinces 21 Canadian collections of mammals with 100 or more specimens, plus about nine smaller or presumably inactive, nonreporting ones. A 1975 survey of most Canadian mammal collections by Jack Dubois of the Manitoba Museum of Man and Nature reported no substantial changes among those reporting.

Canada's largest mammal collection is at the Royal Ontario Museum in Toronto. Six years ago it had around 73 400 specimens, many of which are from foreign countries. This is only the eighth largest mammal collection in North America. In contrast, this continent's largest, in Washington, D.C., contained over 480 000 specimens in 1973. These are in the combined collections of the Smithsonian Institution's National Museum of Natural History and the United States Bureau of Sport Fisheries and Wildlife, Bird and Mammal Laboratories (formerly the Branch of Economic Ornithology and Mammalogy, mentioned earlier, and later the Bureau of Biological Survey). The second largest is in the American Museum of Natural History in New York with 250 000 specimens! Both of these huge collections are also worldwide in scope.

Most of the specimens in the rest of Canada's mammal collections are of Canadian origin, although certain collections have a remarkable diversity of foreign mammals as well. Our second largest and North America's 11th largest is at the National Museum of Natural Sciences in Ottawa, with about 43 500 mammals. Then the next five are at the University of British Columbia, the British Columbia Provincial Museum, Carleton University (surprisingly enough), the University of Alberta, and the Manitoba Museum of Man and Nature. In 1973 their mammal collections ranged from 9525 down to about 6000 specimens. The others ranged from about 2000 downward. Most important Canadian mammal collections are currently being added to by active but selective collecting to fill in gaps in our knowledge of Canadian and foreign mammals. Their value in preserving for posterity for reference and research in perpetuity examples of rare and endangered as well as currently abundant species of mammals will be enhanced as time goes on.

It is time to pass from the story of Canadian museum mammal collections to a broader aspect of mammalogy in North America, and to consider some of the ways in which Canadians have contributed.

The American Society of Mammalogists

After the intense activity in mammal study that took place in the last two decades of the 19th century and the first two of the 20th, mammalogy really came of age as a separate discipline in North America with the founding of the American Society of Mammalogists (ASM) in 1919 and the start of publication that same year of its quarterly *Journal of Mammalogy*, the world's first journal devoted solely to papers on mammals. Of the 60 men and women who attended the founding meeting in Washington, only two were Canadians. Among the approximately 250 charter members who joined the society in 1919 were R. M. Anderson, J. B. Harkin, Hoyes Lloyd, P. A. Taverner, and M. Y. Williams, all from Ottawa, and all but Harkin were active members of The Ottawa Field-Naturalists' Club. Moreover, Anderson was elected to the first Council of the new society. Charter members of the ASM from elsewhere in Canada included Allan Brooks and J. A. Munro from British Columbia; Norman and Stuart Criddle from Manitoba; J. H. Fleming, A. B. Klugh, W. E. Saunders, and J. D. Soper from Ontario; and a sprinkling of others. As mentioned earlier, most students of mammals at that time, whether professional or nonprofessional, were also interested in birds, if not all other vertebrates, and often invertebrates and plants as well, and this was certainly true of these Canadian mammalogists of 60 years ago.

Canada has provided the meeting sites for three of the 59 Annual Meetings of the ASM held up to this year. Successful meetings were held in Toronto in 1948, Winnipeg in 1965, and Vancouver in 1971. I can state with confidence that the latter two were successful because my wife Lorraine and I attended both as active participants. My memories of the 1948 meeting, however, while vivid about the success (for me) of the last session, which I surreptitiously attended as an unregistered awestruck teen-ager, do not permit me to evaluate the whole meeting. Others who attended, however, have since assured me that it was a very worthwhile meeting, as usual. Canadian mammalogists have published many articles in the society's journal, have reviewed manuscripts for it, and have served on society committees, on the Board of Directors, and on the executive. One outstanding Canadian mammalogist, Randolph L. Peterson of the Royal Ontario Museum, served as President for two years from 1966 to 1968. Two prestigious Canadian mammalogists were elected as honorary members of the ASM: Ernest Thompson Seton in 1941 and Rudolph M. Anderson in 1947.

In an attempt to quantify the increase in numbers of Canadians seriously interested in mammal study during the past 60 years, I have used the 15 membership lists for 1920 to 1978 published in the *Journal of Mammalogy* by the American Society of Mammalogists. I tallied the number from each province and territory in each list and compiled the resulting counts as Table 1. This shows that except for a marked decline during the Great Depression of the 1930s and World War II, there was a steady increase in the number of Canadian mammalogists (or at least in the number of mammalogists with Canadian addresses) up to a peak of 231 in 1972, and a leveling off by 1978. Table 1 also shows that Ontario has always had an inordinately large proportion of the total, partly because of the concentration there of mammalogists employed by the federal government. During about the last decade, however, the numbers of mammalogists in Alberta and British Columbia have risen significantly, while the numbers in the provinces east of Ontario and in the territories have remained relatively low.

TABLE 1—Numbers of mammalogists with Canadian addresses in the membership lists of the American Society of Mammalogists*

Province or territory	1920	1922	1924	1927	1934	1937	1940	1945	1948	1950	1953	1959	1965	1972	1978
Yukon Territory												1	1		1
Northwest Territories								1	3	1	4	4	1	3	2
British Columbia	6	5	4	10	5	2	3	4	3	13	15	13	30	25	34
Alberta	3	4	5	3	1	1	2	2	5	5	7	12	29	50	49
Saskatchewan	2	1	2	2	1	1	1	1	2	3	5	7	9	17	10
Manitoba	4	5	4	4	4	4	4	2	3	3	3	4	6	17	22
Ontario	11	13	16	19	15	16	20	16	31	34	44	47	50	81	75
Quebec		2	3	3	4	2	2	1	4	2	4	11	17	20	23
New Brunswick								1	5	6	7	6	6	8	5
Nova Scotia		1			2	1			1	2	1	3	2	4	4
Prince Edward Island	1										1		1	1	
Newfoundland				1						1	1	5	2	5	4
Total	27	31	34	42	32	27	32	28	57	70	92	113	154	231	229

*Journal of Mammalogy 1(4): 201–212. 1920; 3(3): 203–217. 1922; 5(4): 277–293. 1924; 8(4): 327–349. 1927; 15(4): 336–354. 1934; 18(3): 390–407. 1937; 21(4): 483–505. 1940; 26(3): 327–345. 1945; 29(3): 321–343. 1948; 31(2): 220–244. 1950; 35(2): 284–315. 1954; 40(2): 278–312. 1959; 46(1): 128–180. 1965; Supplement to 54(2): 1–69. 1973; Supplement to 59(4): 1–74. 1978.

Jurisdiction over Mammals in Canada

The history of Canadian mammalogy has pretty well paralleled that of Canadian ornithology as described earlier by Fred Cooke. I have already outlined the discovery and inventory periods. The conservation period has been treated at length in the book *Working for wildlife — the beginning of preservation in Canada* by Janet Foster (1978). This describes how dedicated government scientists and bureaucrats took initiatives to conserve wild mammals (and birds) and their habitats, although not always for what we would consider the right reasons. The Canadian conservation story will be dealt with later by Vic Solman.

One major difference between the legal status of mammals and that of birds in this context is that there is no major federal act concerning Canadian mammals. Jurisdiction over mammals (and other groups of wildlife) is

not clearly stated in the British statute that serves as Canada's constitution at present, The British North America (BNA) Act of 1867. As a result there is a complex situation involving divided responsibilities based on interpretation — a typical Canadian situation! It has been broadly interpreted that the responsibility for natural resources (including wildlife) is provincial. Interpreting its authority from Section 92(16) of The BNA Act ("In each Province the Legislature may exclusively make Laws in relation to . . . generally all Matters of a merely local or private Nature in the Province."), each province and territory has passed legislation dealing with mammals and other wildlife. In fact, most mammals in Canada are under provincial or territorial jurisdiction. In spite of this, there are arrangements whereby federal biologists investigate problems of national interest such as diseases, effects of pesticides, and the status and management of endangered species among otherwise provincially or territorially "owned" mammals. All mammals in the territories used to be under federal jurisdiction, but nowadays the only Canadian mammals that are considered a federal responsibility are those in national parks and most marine mammals.

The scientifically anomalous situation whereby whales, seals, and their relatives are under the jurisdiction of the federal government is interesting. The BNA Act, Section 91 (12), states that ". . . the exclusive Legislative Authority of the Parliament of Canada extends to . . . Sea Coast and Inland Fisheries." S. V. Ozere (1961) in his background paper for the Resources for Tomorrow Conference explained that "fisheries" applies to sea mammals as well as conventional fishes, and that the basic statute with respect to fishery regulations — The Fisheries Act — specifically applies to marine "animals." It is from this statute that the Government of Canada derives its power to make regulations for the management and protection of seals and whales, although there are other, more recent acts involving international conventions as well.

One administrative result of the interpretation of The BNA Act to include seals and whales as "fishes" is that all Canadian marine mammalogists are employed by the federal Department of Fisheries and Oceans, unless of course they are associated with universities. Federal, provincial, and territorial biologists cooperate in studying Polar Bears. The single species of marine mammal that is clearly only under provincial jurisdiction at present is the Sea Otter, which has been reintroduced to the coast of British Columbia by provincial wildlife biologists. I suppose we should consider ourselves lucky that Beavers, Muskrats, River Otters, Minks, Water Shrews, and even Moose have not also been declared "inland fishes" and therefore federal responsibilities!

Canadian Mammalogy from Fifty Years Ago

One of my mandates for this paper was to document some of the trends in Canadian mammalogy from 1879 to 1979. There *have* indeed been remarkable changes from the situation I have described for 90–100 years ago when practically no one in Canada was studying Canadian mammals. To assess the status and nature of Canadian mammal study at the halfway point in the century we are concentrating upon today, I turned once again to Canada's primary natural history journal. Volume 43 of *The Canadian Field-Naturalist* had as Associate Editor for Mammalogy the aforementioned Rudolph M. Anderson of the National Museum of Canada, who served our journal in this role from 1918 to 1955!

There were nine numbers in that 1929 volume. In the first, there was a short article about Moose and deer in Nova Scotia. In the second, there were two notes on Smoky Shrews and Brewer's [now Hairy-tailed] Moles by W. E. Saunders of London, Ontario. In the third there was a reply to the Moose–deer article from E. R. Hall, a prominent United States mammalogist; there was also a note on European Hares at Toronto by my late friend Jim Baillie from the Royal Ontario Museum. Number 4 had nothing on mammals, but in Numbers 5 and 6 there were notes on Moose, Black Squirrels, Water Shrews, and Little Brown Bats. In other words, there wasn't a great deal about mammals, but there *was* more than in the early days. Most of the papers in this 50-year-old volume of *The Canadian Field-Naturalist* were still about birds, and there was relatively less about plants, insects, or geology than there had been in the early days of this club.

Number 7 contains "An annotated list of the mammals of Aweme, Manitoba," by Stuart Criddle, a member of a famous pioneer family and later an Honorary Member of this club. In browsing through his article, I was very interested to note, first, that he acknowledged his debt to Merriam, Jackson, and Bailey of the United States Biological Survey for identifying his specimens years earlier, and second, that while he wrote his paper he was aided by a grant from the National Research Council of Canada. Remember that he was an amateur naturalist, a very competent one, and a farmer; unfortunately, the likelihood that such a deserving person would ever receive support from the corresponding federal agency, the Natural Sciences and Engineering Research Council, today is virtually nonexistent. This number of the journal also contained notes on the fluctuation in numbers of rodents and on a Pygmy Shrew record. Number 8 contained a fascinating partial biography of

"William Couper — a pioneer Canadian naturalist" by James L. Baillie, Jr. Couper had collected a bat near Toronto in 1851 and sent it to Professor Louis Agassiz at Harvard for identification, and he recorded notes on mammals in various publications for the next 30-odd years. Number 8 continued with Norman Criddle's recollections of the abundance and habits of mammals (and birds) at Aweme during his boyhood between 1882 and 1890 and comparisons with their 1928 status. The ninth and final number for 1929 contained W. E. Saunders' notes on certain shrews and rodents he had trapped that summer.

When the first mammal article I came to in Volume 44 of *The Canadian Field-Naturalist* for 1930 turned out to be "Barney Woodchuck," the story of a family pet, I decided to quit on the previous high points and I concluded my survey of mammal articles in the club's journal of 50 years ago. Clearly they were mostly short reports of specimens, original observations, and opinions written by both amateur and professional naturalists from several provinces, but they revealed a much greater abundance and diversity of interest in mammals than 40–50 years earlier.

The trends in research on Canadian mammals between 1931 and 1970 were documented in Volume 86 of *The Canadian Field-Naturalist* in 1972 (pages 217–221) by Anne Innis Dagg, and I recommend that you look up this interesting compilation for the details. Not surprisingly, the increase in numbers of papers on Canadian mammals since 1931 roughly paralleled the increased number of Canadian mammalogists I mentioned earlier. *The Canadian Field-Naturalist* published the most papers in that period, but the *Journal of Mammalogy*, the *Canadian Journal of Zoology*, and the *Journal of Wildlife Management* were also important media for publication of Canadian mammal papers, the latter two especially in the 1960s. She found that university people had done more mammal research in these decades than had other categories of researchers, and that the University of British Columbia (UBC) was the leader by far, because of the impetus of Ian McTaggart Cowan. He was the author or coauthor of fully 49 mammal papers during the four decades Dagg surveyed!

In the early 1950s when I was considering where to do graduate studies in mammalogy, there were only two serious possibilities in Canada — UBC or the University of Toronto. Both of these great universities are still active centers of mammalian research, and in addition there are other Canadian universities offering excellent programs of graduate study in at least some aspects of mammalogy: from the west towards the east, Simon Fraser, Alberta, Calgary, Manitoba, Laurentian, Windsor, Western Ontario, Waterloo, Guelph, York, Carleton, McGill, Montreal, Laval, Acadia, and perhaps others.

Dagg reported that the absolute numbers of Canadian mammal papers published by non-Canadians per decade have remained fairly constant over the four decades, while the outputs by workers at universities and federal and provincial employees have all steadily increased. Mammal papers by "unaffiliated Canadians" (= amateurs?) were most numerous in the 1940s and fewest in the 1960s but have generally been scarce, in contrast to earlier times!

Canadian Books on Mammals

So far I have said a great deal about reports about Canadian mammals in the scientific periodical literature, especially in *The Canadian Field-Naturalist*, and I have mentioned museum research series and other museum publications, but I have scarcely mentioned books on Canadian mammals. During the discovery phase, reports on Canadian mammals were all published in Europe and there were no books on Canadian or North American mammals. During the inventory phase, some early mammal books published in the United States were of use to the few Canadians interested in the study of mammals, and mammal books published south of the border have continued to be pertinent to Canadian mammalogy right up to the present time. In fact, some have been indispensable. But gradually, Canadian books have been written on Canadian mammals, and I'd like to mention a few of the most important.

In 1909 the famous naturalist Ernest Thompson Seton (whose mammal specimens appear in various museums as collected also by Ernest E. Thompson or Ernest Seton Thompson) published his *Life histories of northern animals: an account of the mammals of Manitoba.* He combined his own observations and anecdotes from many sources to expand this two-volume work into the famous four-volume *Lives of game animals* which was completed in 1929, and dealt in detail with northern carnivores, ungulates, and some rodents.

The first modern scientific inventory was R. M. Anderson's *Catalogue of Canadian Recent mammals* hopefully dated 1946, but which appeared early in 1947. The first important species monograph was R. L. Peterson's *North American Moose,* published in 1955. This was followed by two more outstanding books on northern ungulates: *Muskoxen in Canada: a biological and taxonomic review* by John S. Tener in 1965, and *The migratory Barren-ground Caribou of Canada* by John P. Kelsall in 1968. The most outstanding provincial handbook on mammals, *The mammals of British Columbia* by Ian McTaggart Cowan and Charles J. Guiguet,

was published in 1956 and revised in 1965. The next year R. L. Peterson's *The mammals of eastern Canada* appeared and provided students of mammals in the six provinces from Ontario eastward with useful keys for identification, detailed range maps showing specimen localities, and an authoritative text. The last major book I'll mention is *The mammals of Canada* by A. W. F. Banfield, which in 1974 made available a vast amount of information on Canadian mammals collected by the author and many others.

Modern Methods and Advances in Mammalogy

Earlier I described the snap-trap revolution of 1887 or 1888 that led to the collection of large series of small-mammal specimens and hence to the rapid growth of mammal collections. Thus it led to a great increase in knowledge of the taxonomy and distribution of North American mammals, at first in the USA but later in Canada too. The next important advance or revolution in mammalogy was the adoption of live-trapping, a practice that started in the United States shortly after World War I. After being examined in detail, a live-trapped mammal is marked or tagged for individual recognition and released. It may be observed subsequently in the free-living state or it may be retrapped, sometimes repeatedly at intervals. A great deal of sequential information on individual living mammals may be gathered, sometimes over periods of years. Thus much information about the behavior, ecology, and life histories of mammals can be obtained; generally such information was unavailable from the dead mammals that most earlier mammalogists were forced to study. Indeed, the late, eminent United States mammalogist Tracy Storer called live-trapping "the most important single method in mammalogy." It has certainly been much used in Canada over the past few decades and is currently still in vogue and yielding worthwhile information.

A related technique that yields comparable results for one particular order of mammals but which may be more familiar to students of birds is banding, in this case of bats. Bat-banding began with the banding of four bats by an ornithologist in the USA in 1916, carried on in a small way there in the 1920s, and started on a reasonably large scale in 1932 in Germany and the United States. The first Canadian bat-banding was done by Harold Hitchcock of the University of Western Ontario in the late 1930s and even after he returned to the USA, he continued to band bats in Ontario and Quebec until 1961. Since I took over his Canadian bat project in 1962, my students and I have continued to monitor his banded bats (and our own) on our annual visits to their hibernating sites. Our most remarkable recoveries of Hitchcock's banded bats were in 1976 and 1977 when we found hibernating two Little Brown Bats (*Myotis lucifugus*) that he had banded in 1947; their minimum ages were 29.5 and 30.5 years, the world's record longevities for bats of all species!

There is another technique whose introduction has completely revolutionized the study of bats. In the late 1940s some North American ornithologists picked up from the Japanese the use of fine nylon mist-nets. Before long mammalogists began using mist-nets at night to capture bats. Soon knowledge of the distribution, behavior, and ecology of bats expanded by leaps and bounds especially in the tropics, but relatively little netting was done in Canada. The major advances in knowledge of Canadian bat biology, largely by my colleague Brock Fenton and his students at Carleton University, and many other advances in mammalogy generally, came in the 1970s as a result of yet another revolution, the last one I will describe.

All the major advances in mammalogy I have outlined have come about through the application of new techniques made possible by the invention of devices or pieces of equipment. I might also mention that the increasing use of diverse terrestrial wheeled and tracked vehicles including snowmobiles, of a variety of watercraft, and of aircraft, both fixed-winged and helicopters, has increased the scope and practicality of field work in remote places. Over the past decade or so, the use of increasingly sophisticated equipment of a variety of types has been expanding, and this too has resulted in a striking increase of our knowledge of mammals. I call this latest revolution the modern technological revolution. Mammalogists, including Canadian ones, have lately been using radioactive isotopes, Geiger counters, tape recorders, video cameras, night-visionscopes, fluorescent dyes, ultrasonic detectors, computers, and more. The use of tranquillizing drugs in darts shot by guns has allowed the collection of information on live mammals somewhat larger than the ones that can be readily trapped and handled. This technique also permits the attachment of telemetric devices that continue to transmit information not only on the location of the mammal but also on a variety of physiological variables and activities long after its release. The miracle of miniaturization, involving increasingly tiny transistors, microcircuit-bearing chips, and other wonders of modern electronics, has permitted transducers of less and less bulk and mass to be attached to smaller and smaller mammals so that we are starting to obtain information about free-ranging mammals of almost the whole gamut of sizes. All in all, employment of the whole array of these devices has opened up vast new areas of field research on the behavior and ecology of shy, secretive, and especially nocturnal mammals.

Modern Canadian Contributions to Mammalogy

Canadians have been prominent in the development and use of several of these techniques, from live-trapping to bat detectors. Canadian mammalogists have also carried out some of the world's most ambitious integrated field research projects on large mammals. Over periods of years, teams of government biologists have collected data on Caribou, Muskoxen, Polar Bears, Gray Wolves, Harp Seals, and others, so as to better understand and manage our populations of these precious mammals. From the early days of the discovery period, when British and other European naturalists were the experts on Canadian mammals, to the inventory period when Americans took over this role, we have progressed to the present situation where we have a sizable group of active Canadian mammalogists expert in various subdisciplines. Indeed some, such as R. L. Peterson and Brock Fenton, who specialize in the study of bats, are world authorities in their fields. The late Douglas Pimlott was one of the world's top experts on wolf biology. In the past two decades Canada has reversed the flow and has become a supplier of mammalogical talent to the world. Among the experienced Canadian mammalogists our federal government has loaned to Third World countries especially in East Africa to do research, teach, and advise are Allan C. Brooks, John Tener, J. Bristol Foster, John Bindernagel, and C. H. D. Clarke.

Well, that concludes my story of some of the highlights of Canadian mammalogy. Time has permitted me to say little of applied mammalogy, part of wildlife management, or about studies of marine mammals, or about many other aspects of field-oriented mammal study in Canada. But I hope I have put across some of the tremendous transitions that have taken place in this branch of biology in Canada, and how certain external and internal situations, certain individuals, and certain inventions have stimulated the progress of mammalogy in Canada.

The future? We still have most of our Canadian species of mammals, although the numbers of some are precariously low, and there is still a great deal to be learned about most of them. We need to continue our inventories of mammals in remote areas of Canada and to work out some of the details of their life histories, physiological and behavioral adaptations, population dynamics, and management. We need to increase our recent upsurge of interest in establishing the status of rare and endangered species of mammals in Canada and elsewhere and to practice sound conservation measures to maintain these species and their habitats.

I referred much earlier to the somewhat premature prediction of one of the early presidents of The Ottawa Field-Naturalists' Club to the effect that after about eight years of existence and study they would have discovered about all there was to know about the plants, birds, fishes, etc. of the Ottawa district. I think that now, almost a century later, we realize that in spite of all the knowledge we have acquired, we still have a long way to go to learn about the mammal faunas of Ottawa, of Canada, and of the world. There is still much that can and should be done locally, nationally, and internationally, and many contributions to be made by both professional and amateur Canadian mammalogists.

I have tried to show today that The Ottawa Field-Naturalists' Club, mainly through its publication of *The Canadian Field-Naturalist* and its predecessors for the past century, has already played a major role in stimulating Canadian mammalogy. I hope that by continuing its almost unexcelled longevity, vitality, and especially its valuable role in integrating the activities and reports of amateurs and professionals, it will go on contributing to the development of Canadian mammalogy for many more centuries.

Canadian Entomology of the Last Century[1]

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Entomology has one interesting parallel with ornithology and one marked contrast. The parallel is that both groups of researchers seem to be concerned with numbers. The ornithologist is trying to determine the number of individuals of the species in each habitat. The entomologists are still trying to determine the number of species of insects in Canada. The contrast is that most of the activity and particularly the federal activity and federal regulation in ornithology is concerned with protection; in entomology it is concerned with extermination.

As Donald Smith did, I would like to go back a little farther than 100 years. As far as I can determine, the first insect described from a Canadian specimen was a long-horned beetle, *Leptura canadensis,* described by a French entomologist in 1795. For the next 30 years or so, I have been able to find two short papers describing specifically Canadian insects collected on arctic expeditions. Then, in 1837, what I would consider the first major paper on specifically Canadian insects and their classification appeared.

As with mammals it was in *Fauna boreali americana.* The material was collected by Richardson between New York State and the arctic posts of Canada, and it was treated by a British clergyman, William Kirby. He described in reasonable detail 447 species and appended a list of 103 species which previously had been recorded in Greenland and the northern parts of North America. This made a total of 550 species, and this is, in effect, the first catalogue or checklist of Canadian insects.

By the early 1860s there were a number of moderately active amateurs in eastern Canada who published in two general scientific journals, one in Toronto and one in Montreal. In 1857 the Professor of Chemistry at Toronto, H. Y. Hind, and l'Abbé Léon Provancher, in Quebec City, each published a paper on the insect pests of wheat. This probably marked the beginning of economic entomology in Canada.

In 1862, 10 entomologists held a meeting in Toronto. This sounds like a very insignificant thing, but this was really the beginning of developed and consistent entomology in Canada. The meeting was arranged by C. J. S. Bethune, a young clergyman, and William Saunders, a druggist in London, Ontario. The next year, in 1863, they founded the Entomological Society of Canada with 25 members. Five years later they began publication of their journal, *The Canadian Entomologist.* This journal became the entomological publication with the longest continuous period of publication in North America. There had been several in the United States before this, but at one time or another they ceased publication and disappeared. The introduction to Volume 1, Number 1, in August 1868, is rather interesting.

> For a long time the wielders of the butterfly net and beetle bottle in Canada have been longing for some medium of inter-communication — some mode of telling one another what they have taken, how and where they have taken it, and what they are in want of. This desire the Entomological Society proposes now to satisfy to some extent by the publication of *Canadian Entomologist.* It is but a few years since the Society itself began as a little germ with a few members, and now we find it rapidly growing into a goodly tree with its main trunk in Toronto, its thriving branches in London and Quebec, and its scattered adherents all over the country . . .

I did not check the contributors to the first volume, but the second volume in 1870 had 180 pages and 20 contributors of whom 10 were Canadians and 10 Americans. In contrast, Volume 110 last year, the last complete volume, had almost 1400 pages and about 250 contributors. The Society began with 25 members; at present it has about 1000.

The Abbé Provancher in Quebec City was the first important Canadian insect taxonomist. In 1868, the same year that the Canadian Entomological Society was begun, he began a journal, *Le Naturaliste canadien,* and he was the main contributor until he died in the 1890s. He also wrote *Petit faune entomologique du Canada* between 1877 and 1890. It totalled almost 3000 pages and contained descriptions of several thousand Canadian insects, especially parasitic wasps.

Public support for entomology began in 1870 when the Ontario government gave the Entomological Society of Canada $400 a year, provided it publish an annual report on noxious insects and continue to publish *The Canadian Entomologist.* Shortly afterwards, the Entomological Society of Canada was reorganized as the

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[1]This paper was presented on 19 May 1979 at The Ottawa Field-Naturalists' Club Centennial Symposium entitled *100 Years of natural history in Canada.*

Entomological Society of Ontario, which, in effect, remained the national society until 1950 when the Entomological Society of Canada was reestablished.

In 1884 James Fletcher, an accountant in the Parliamentary Library in Ottawa, was appointed honorary entomologist to the Canadian Government. Two years later the Experimental Farm Service was started with Saunders, the druggist from London, appointed as the first director. Fletcher then became Dominion Entomologist and botanist. He had almost no staff, but he did have 400 observers scattered across Canada who reported on noxious insects enabling him to publish a series of annual reports on insect pests.

Legislation aimed at controlling the introduction and spread of insect pests began in Prince Edward Island in 1883 against the Potato Beetle, and in Ontario and Nova Scotia in 1888 against the San Jose Scale.

Instruction in entomology as a subject in universities began in 1877 at the Ontario Agricultural College in Guelph and in 1888 at the Nova Scotia Agricultural College in Truro. Gradually, many other colleges and universities began giving formal instruction in entomology.

During this period, entomology was still largely a field for amateurs. There were a few people who did become professional entomologists, such as Fletcher, who became Dominion Entomologist, and Bethune, the other cofounder of the society, who became professor of zoology and entomology at Guelph early in this century. They, as well as the other professionals, had not been trained as entomologists, and usually not as zoologists.

Then, in 1909, Gordon Hewitt, who had trained in zoology and entomology in England, was appointed Dominion Entomologist. He was the first trained professional in the field and was a very active and forceful man. The Insect and Pest Control Act was passed by the federal government in 1910 in an attempt to control by regulation the spread of insect pests within the country. Hewitt, between 1911 and 1919, established federal government entomological laboratories in all the provinces except Prince Edward Island. He also began to give attention to forest entomology which previously had been completely neglected in Canada. The initial work by the employees of the federal government was largely devoted to control measures, but gradually, especially from 1945 on, they began to be concerned with all aspects of insect biology, nutrition, metabolism, toxicology, cold hardiness, population dynamics, pathogens, etc.

In 1945 the Department of Agriculture had about 140 full-time entomologists employed and in 1956 over 350. I do not know the present number, but there has been a substantial and unfortunate decrease from 1966 to 1976. University entomology, of course, increased greatly at the same time, and most Canadian universities, I believe, now have courses in entomology; 12 or more give graduate degrees in this field.

Now I would like to say something about the Canadian National Collection of Insects which I regard as the center of entomological research in Canada (perhaps because I have been associated with it for almost 30 years). I am sure many people would disagree.

The collection was established as the Canadian National Collection of Insects in 1917, and because of a peculiar accident it is in the Department of Agriculture rather than the National Museum.

In 1915 it was observed that the Department of Agriculture had a small collection of insects which had, as a nucleus, Fletcher's private collection of 1887. This modest collection grew as a few other collections were donated, and members of the Entomology Branch across the country contributed specimens. The Biological Division of the Geological Survey also had a small collection. It consisted, in large part, of the material collected during the Canadian Arctic Expedition during the First World War. Both of these collections consisted mostly of butterflies and moths. It was considered reasonable to combine the two collections, and they were to go to the Biological Division of the Geological Survey (now the National Museum of Natural Sciences), but in 1916 the Parliament Building burned down and space had to be found to house Parliament until the buildings were replaced. It was decided that the Victoria Memorial Museum would serve the purpose well, and so Parliament moved here, probably meeting in this very hall. To make as much room as possible for the law makers, the insect collection went to the Department of Agriculture, where it has remained ever since.

The first full-time insect taxonomist in the Department of Agriculture was James McDunnough, a Canadian, who had taken his graduate training in Germany. He was appointed as Head of Systematic Entomology in 1919 and published an account of the collection at that time. The following are some figures indicating growth in the collection and staff. In 1931 there were three professional taxonomists on staff, in 1947 six, in 1956 twenty-three — a fourfold increase in nine years — and in 1979 twenty-six, with prospects of slight increase in the future. In 1910 there was about 200 drawers of insects in the combined collections. When McDunnough was appointed, there were 700 drawers; in 1926, 1550 drawers; in 1956, 8000; and in 1960, 10 500. I do not have a definite recent figure, but my estimate of current holdings would be about 17 000 drawers.

As far as individual specimens are concerned, I have no figure before 1956 when a carefully prepared estimate was 3 million specimens. The present estimate is somewhere between 9 million and 11 million. Much of this

material was added by members of the staff of what is now the Entomology Section of the Biosystematics Research Institute. The earlier surveys were rather sporadic. Staff members would go to parts of Canada in which they had an interest or where it was felt insects were poorly known, and would spend a few weeks or a few months collecting and preparing specimens for the collection. In 1947, the first and most concentrated effort to build a Canadian national collection began, largely under the direction of T. N. Freeman. This was the Northern Insect Survey. The Department of National Defence had established bases in the North. The DEW (Distant Early Warning) line sites were either being built or being considered, and for some reason they found the biting flies a serious problem. As a result, the Department of Agriculture was asked to undertake studies of the biting flies. This led to survey parties which, between 1947 and the early 1960s, visited about 70 localities in northern Canada. Their task was to collect and obtain information on biting flies and other insects. The "other insects" were a great boon, because members of the party could do a reasonable amount of work on biting flies and then collect the other insects in which they were particularly interested.

At the same time three northern laboratories were established for the study of life histories, habits, ecology, and control of biting flies. The main laboratory was at Fort Churchill and for a few years similar studies were done at Whitehorse and Goose Bay. This Northern Insect Survey provided probably a million specimens of arctic and subarctic insects, which gave the Canadian National Collection by far the largest collection of arctic insects in the world. I always thought that probably the Russians, with their apparent emphasis on northern development, were also collecting very large numbers of arctic insects. This seems, however, not to be the case. In 1966 one of my colleagues, another dipterist, spent a month in Leningrad where the major Soviet collections are housed, and in 1969 I was there for a week. Unless the Russians have large collections which they didn't show us, which I think is extremely unlikely, both of us got the impression that their total collection of arctic flies would be the equivalent of what one reasonably competent party of two people would collect in one summer in one locality in arctic Canada. This indicates that we have probably 40–60 times as many arctic flies as the Russians have in Leningrad. Admittedly the arctic tundra is a very much smaller part of the total area of Russia than it is of Canada, probably 5% as compared to 30%, but the Russians seem to have done surprisingly little collecting in the arctic and not very much more in the northern boreal forest.

The Northern Survey has never officially been terminated, but from about 1960 on emphasis started to switch to surveys of more southern parts of Canada. These have continued since. Occasionally rather large parties have gone to a particular area for the summer. More recently, individual people have gone out to areas of particular interest, and more and more tend to deal with the particular group thay interests them. The Northern Survey parties that went out in the 1950s and 1960s made an effort to collect insects in general. This usually meant that the members collected groups of insects in which they were interested, and other groups that they obtained using the same collecting methods.

In 1976, the Biosystematics Research Institute began publishing a series of handbooks of Canadian insects. The first one was on the bark beetles. Since then, two handbooks on small families of bugs (Hemiptera), and one on crab spiders, have appeared. Five more on the plant bugs of the prairies, spittlebugs, mosquitoes, the genera of Canadian caddis flies, and the fleas of Canada, Alaska, and Greenland will appear this year or next year.

One major project, I believe the largest single work that Entomology in the Biosystematics Institute has undertaken, is almost reaching its conclusion. In 1934 C. Howard Curran, who from 1922 to 1928 was the dipterist in the Entomology Branch, published a manual of genera of North American flies. He had been working as a professional entomologist for 12 years. The section on one major family was contributed by someone else, but Curran did most of the rest of the work himself. It was a magnificent piece of work, but as is almost inevitable, it was becoming out of date. In the early sixties one of our staff members suggested that we should revise it. We postponed this until 1965 when the United States Department of Agriculture published a catalogue of the known flies of North America. That year or the next year we began working on a manual of the genera of North American flies. There are about 40 contributors, and this year the first of two volumes are finally going to press. Maybe there is something to be learned from this. What Curran did by himself in 12 years from the time he started work as a dipterist now requires 40 people working for 13 years. It is going to be a much bigger and better work than Curran's. It will have well over 1000 pages, will treat 2000–3000 genera, will have roughly that number of illustrations, and will include extensive sections on morphology, biology, classification, distribution, and so on.

Whereas I have been concentrating in this talk on the Canadian National Collection and its work, there are a number of other major collections in Canada, most of which tend to specialize on one or a few orders of insects. The Lyman Collection at Macdonald College began largely as a collection of Lepidoptera, but a number of the staff members there are interested in Orthoptera–grasshoppers, crickets, and so on. It has now become a major

collection of Canadian, and, in some groups, world Orthoptera. The Royal Ontario Museum has undoubtedly the largest collection in Canada of Odonata (damselflies and dragonflies), the speciality of E. M. Walker. It has also a large collection of Orthoptera, and, in recent years, Glenn Wiggins has developed a very large collection of North American caddis flies. The University of Alberta has good general collections of insects and a very large collection of North American Carabidae (ground beetles). The University of British Columbia has a good collection of British Columbian insects. There are, of course, many others, but these are, I believe, the four largest outside the collection in Ottawa.

I would like to give you some indication of the increase in number of known species of butterflies in Canada. A brief digression may be desirable here. This is what we are trying to do — to get to know, and to make known, all the species of insects in Canada. When I stop to think what "known" means, it occurs to me that it means pitifully little. It means that one or more specimens of a species are in collections, that a name for and description of the species have been published, and that, hopefully, the description is sufficiently diagnostic for the species to be easily recognized by later workers. In most cases this is all we know. We all too often know little or nothing of the life history, the nature of the immature stages, or the economic or biological role of the species. By "known" I fear I mean that we can apply a name to the species, but even this is a beginning.

In 1894 Bethune reported 133 species of butterflies from eastern Canada. There were undoubtedly a few more reported in the literature or known to him from western Canada, but I doubt the total would be much more than 150 butterflies from all of Canada. There are now 262 known. In the last 10 years, I was surprised to find that about 12 butterflies have been added to the Canadian list. One of these was a new Ontario species of hairstreak, collected, recognized, and described by Donald Lafontaine, who has been an active member of this club. Four or five species new to southern Ontario have been collected in the last 10 years. Five new to Canada have been taken in the Cypress Hills. Donald Lafontaine found two species new to Canada from British Columbia in material that was already in the collection. A new species of *Boloria,* one of the small fritillaries, is known from the Yukon; Ken Philip in Fairbanks, who is making a special study of northern butterflies, will be describing this. Donald Lafontaine's estimate is that probably another 10 will be found in the next 10 years, and he thinks that over a long period after, that perhaps another 10 species will be found provided the climate remains constant. If the warming trend that has been going on for some time and that may be responsible for the northward movement of birds and insects continues, Lafontaine says we could quite easily have a number of species moving north from the United States. In 1866 a list of insects of British Columbia included 22 species of butterflies. The last complete list that I could find was from 1927 in which 133 were recorded.

A few words now about the state of knowledge of other Canadian insects. Five years ago the Entomological Society of Canada proposed the establishment of a biological survey of the insects of Canada. The initial plan was to study the need for it and the feasibility, and the methods that should be used. This initial work has resulted in the publication last month of what I think will probably be the most useful work on the Canadian insect fauna that has yet appeared. It is called *Canada and its insect fauna,* and apart from having extensive sections on Canada as an environment for insects and on the geological history of insects in Canada, it has a lengthy section, order by order and family by family, on the Canadian insect fauna. For almost every family there is a brief outline of the general biology and distribution in Canada, its economic importance, or its particular role in other studies. There are tables of known and probable total species numbers for each family of insects and for the other groups of terrestrial arthropods — the spiders, mites, and crustacea and the smaller groups such as centipedes, millipedes, etc. One feature of major importance is that for the first time we have a reasonably reliable estimate of the number of species of each of these groups that probably occur in Canada. For the insects, earlier estimates were 60 000–80 000; the brief in which the establishment of this pilot project in connection with the Biological Survey of the Insects of Canada was first proposed had an estimate of 90 000 species. The present estimate is between 54 000 and 55 000; this figure may be off by a few thousand, but it is probably fairly reliable. Of these, 30 000 are known in Canada and 24 500 are unknown; I have mentioned earlier what "known" and "unknown" means. We know little more than the appearance of dead specimens for perhaps 90–95% of the "known" species. On the other hand, it is estimated that about 55% of the species have been named and recorded, either recorded in the literature or present in the Canadian National Collection or other collections as identified specimens. Unfortunately the immature stages of only about 10% of the species have been described.

Three important orders of insects, as well as a few very small and less important orders, are well known, with 90% or more of the estimated species described. These three orders are Orthoptera (grasshoppers, crickets, etc), Odonata (dragonflies and damselflies), and Siphonoptera (fleas). However, whereas over 90% of the immature stages of 194 species of Odonata are known, only 4% of the larvae of the 180 species of fleas have been described.

For the other major orders, it is estimated that 75% of the beetles have been recorded, 45% of the flies, 70% of the moths and butterflies, and 37% of the Hymenoptera (sawflies, ants, wasps, and bees). The main reason the Hymenoptera appear to be so poorly known is that of the two large groups of parasitic wasps, the ichneumonids with an estimated 7000 species, and the chalcids with an estimated 4000 species, only about 25% have been identified and recorded. In contrast, you have heard figures earlier today of the numbers of species of mammals and birds in Canada. A recent estimate by Bernard Boivin of the number of species of vascular plants is 3060, but in contrast one family of parasitic wasps is estimated to have 7000.

For other terrestrial arthropods the figures vary widely. About 90% of the spiders are known, but of the mites only 2000 of an estimated 9500 species are known (scarcely over 20%), and there are only two full-time mite taxonomists in Canada. One has been active for about 15 years, the other for three or four — these two people are trying to cope with some 9500 species of Canadian mites.

Larvae, the immature stages of insects, are about 10% known, but within the flies and within all other orders, the number varies greatly with different families. All the larvae of the 74 species of Canadian mosquitoes have been described and can be identified quite readily. On the other hand, in the Dolichopodidae, the long-legged flies — bright metallic green flies which I am sure all of you have seen in your gardens on leaves, with wings out at an angle — with an estimated 800 species, only five of the larvae are described, which is just over one-half of 1%.

Donald Smith has referred to a major breakthrough in the collecting of mammals, as a result of improved techniques. I think there is an equivalent breakthrough in the collecting of insects. This was not developed in the United States. A Swedish entomologist, Malaise, in 1934 was collecting insects in the mountains of northern Burma; he noticed that a lot of insects flew into his open tent and collected on the window at the back. He took a tent, removed the two end walls, and placed one of them at the middle of the tent to act as a barrier. At the highest point of the roof he put a collecting jar with a killing agent. Insects flew into the tent, hit the barrier, flew up to the highest point, and ended up in the jar. His catches were enormous. In 1937 he published an account of his trap, but it was, I think, only in the 1950s that other entomologists, particularly in Canada and the United States, began to use them. They are now used everywhere. They collect insects 24 h a day, and even collect during rain. Endless new designs are being produced: some are X-shaped, some are 10 m long, some are miniatures for low-flying insects, some can be hoisted into trees. They have revolutionized the collecting of flying insects, especially flies and parasitic wasps. The number of species new to the Ottawa area that we have obtained from Malaise traps in the last 15 years is frightening. We consider the Gatineau Hills north of Ottawa to be the best collected area in temperate Canada (only one area in the high Arctic is probably more thoroughly collected). About 5 years ago one of my colleagues set two Malaise traps 50 km north of Ottawa — one on top of a high hill, one in a sphagnum bog. Week after week he would bring his catches in, we would go through them, and there would be more and more species we had not seen in Canada. Fortunately he gave up long before the summer ended!

I would, finally, like to say something about the role of amateurs in Canadian entomology. As I said earlier, they began entomology in Canada in about 1860. They were *the* entomologists. They continued in some numbers until the 1940s or 1950s by which time most of them were rather old; very few of the group of amateurs who were active in the 20s and 30s are alive today.

In a talk on 100 years of Canadian entomology given by G. J. Spencer of the University of British Columbia in 1963, he commented on this decline in amateurs and pointed out that at least in southern British Columbia the rising generation had far too many distractions. He mentioned a number of these — sports cars, swimming, skiing — but surprisingly omitted television and rock groups. I think, however, that this trend may be reversing. One group of amateurs I would like to mention in particular are those associated with Bourget College in Rigaud, Quebec. Father André Larochelle has long been a student of the Carabidae (ground beetles) of Quebec, and he seems to be developing an interest in insects in many of the teachers and students. One of the teachers, Raymond Hutchison, occasionally visits the Biosystematics Institute here in Ottawa. He tells me he has had great success in interesting students of 10–14 yr of age, at summer camps where he teaches natural history, in various groups of insects. He trains them to recognize insects and to observe them; at the end of a few weeks with a group of students, many of them will recognize the larger and more abundant species in a group. Their enthusiasm is strong, I sincerely hope they retain their interest.

I do not really think it is necessary to indicate what amateurs can do. There are many things. They can rear insects and can obtain life history data and material of unknown immature stages. They can collect insects in the field, make observations on behavior, or, if they wish, specialize in the taxonomic study of a group of insects. They can do almost anything a professional entomologist can do unless elaborate equipment is needed. Unlike

birds and mammals, insects can be collected without a permit (except in national and some provincial parks). There is, as far as I know, only one protected species of insect in Canada, the West Virginia White, *Pieris virginiensis,* in Ontario. Insects are easy to collect; they are easy to preserve; one does not have to spend hours skinning or otherwise preparing them, so the field is wide open for amateurs. Amateurs can make endless contributions.

Geology, 1879–1979[1]

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One hundred years ago, Canada was at a singularly interesting stage in its development. Sir John A. Macdonald had defeated Alexander Mackenzie in the general election of 1878. Sir John was determined to push ahead with his dream of a railway spanning the continent, to bring British Columbia truly into Canada. Visionary the idea was, because there were then only 23 000 people west of Lake Superior, whereas the population of eastern Canada had already reached three and a half million. But it was a somewhat static populace because roads were still in their infancy. Canals and rivers provided the main transportation routes during summer months. The great railway era was beginning, Toronto having been connected by rail with Montreal only in 1856.

Three years before the year that is in our minds today, in 1876, the Intercolonial Railway, linking Halifax with Montreal, had been completed. The Chief Engineer of this great pioneer work was Sandford Fleming (an early member of The Ottawa Field-Naturalists' Club). Although construction of the line did not result in any mineral discoveries (as did other early railways), Fleming had a real appreciation of the importance of geology. This is clearly shown in his notable book on *The Intercolonial* in which he included geological descriptions of the main divisions into which he had partitioned the line (Fleming 1876). And in the vicinity of Trois-Pistoles, excavation of necessary cuttings was plagued by landslides in the Leda Clay (already so named by J. W. Dawson). All early travelers — between Montreal and Halifax — could see the scars left by these slides.

Sandford Fleming was also the Chief Engineer of the Canadian Pacific Railway, directing the vast task of surveying for the route finally to be chosen and supervising the expenditure of the $14 million spent on initial construction by government, under Mackenzie. He resigned from this post in 1880, geological factors looming large in the proceedings of the preceding parliamentary inquiry into the railway's progress.

The Canadian Pacific Railway (CPR) Company was formed on 17 February 1881, all the work done up to that time being transferred to it under the master agreement. On 1 January 1882, William Cornelius Van Horne took up office as General Manager. What followed, completion of the line from Montreal to Vancouver in less than four years, is part of the folklore of Canadian history. How many Canadians, however, know that Van Horne was a keen amateur geologist? As a schoolboy he had been fascinated by Hitchcock's *Elements of geology*. He spent the first 25 cents he ever earned for the first of five exercise books into which, over a period of five weeks, he copied the full text of this book, every illustration, and even the index! (Vaughan 1920).

He became an avid collector of fossils around Joliet, Illinois, where he lived. His collection soon included crinoids, trilobites, brachipods, and fishes, some not then classified. In later years, nine specimens were named after their discoverer and are today to be seen in the Field Museum of Natural History in Chicago. Canadians think of Van Horne, later to be knighted by Queen Victoria, as one of themselves. It may, therefore, be recorded that with a group of friends he founded the Agassiz Club of Joliet of which he was the first president. He corresponded with many eminent geologists, including James Geikie of Edinburgh after the latter's visit to Canada. Even on his early inspection trips along the CPR, he would spend time searching for fossils. The pressures of his work soon terminated this pleasant diversion but his interest in geology remained.

This is well shown by the support that he gave to the study of geology along the entire route of the new railway during its construction, by officers of the Geological Survey of Canada, notably by A. R. C. Selwyn, G. M. Dawson, and Robert Bell, all of whom were later to be directors. Their reports will be found in Survey publications, but Principal J. W. Dawson of McGill published a general account in the Quarterly Journal of the Geological Society of London, after presenting his paper on the CPR to the society on 23 April 1884 (Dawson 1884). Dawson mentions in this paper not only the work of the Survey geologists but also the remarkable collection of Silurian fossils collected from the banks of the Red River by J. H. Panton, an amateur geologist, even in those early days and in such a pioneer community. This tradition of combined official and unofficial, professional and amateur interests in Canadian geology has continued throughout the century now being celebrated. It is only to be regretted that few of the amateurs have left any record of their work, but of their enjoyment in their hobby we may be assured. One would like to know more about the work of Charles F. Newcombe (1851–1924) on Vancouver Island, and of others like him.

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[1]This paper was presented on 19 May 1979 at The Ottawa Field-Naturalists' Club Centennial Symposium entitled *100 Years of natural history in Canada.*

Such was the interest of the public in both railways and geology in those early days that there was published in 1879 *An American geological railway guide* "giving the geological formation at every railway station, and its altitude above mean high water, with notes on interesting places on the routes, and a description of each of the formations." The author was James Macfarlane, who acknowledged the assistance of the State Geologists "and other Scientific Gentlemen." A second edition was published in 1885 to which George M. Dawson contributed a 32-page section on the Dominion of Canada. The notes accompanying the interesting tables of railway routes, with mileages and elevations, provide (in the smallest legible type) a fascinating guide to the geology of Canada as it was then known (Macfarlane 1885).

It was during the construction of the Canadian Pacific Railway that, in a cutting near Sudbury, Tom Flanagan, a blacksmith in one of the construction gangs, noticed some rock stained with iron oxide and on digging found copper sulfide. This was in 1884 and proved to be the beginning of the discovery of the vast nickel ore deposits, a geological phenomenon now known around the world. It is interesting today to note that so little was its value originally realized that a patent for the lot was granted the next year to a certain Thomas Murray for $1 a year! (Gibbon 1935).

In a similar way, when the Temiskaming and Northern Ontario Railway (now the Ontario Northland Railway) was being constructed as a development line, in the face of much skepticism, a similar discovery was made in 1903 near the crossing of the Montreal River. Fifty years ago when in Cobalt, I was assured by an eyewitness that a blacksmith threw a hammer at a jackrabbit, missed the animal, but dislodged a piece of bedrock, revealing an unusual-looking material which proved to be native silver, the beginning of the Cobalt boom, and the opening up of so much mining in this part of northern Ontario and the adjacent part of Quebec (Legget 1973).

With geological discoveries such as these "making the news," it is not surprising to find that in the closing two decades of the last century, and around the beginning of the 20th century, geology in Canada was a subject of wide and general interest. A succession of geological disasters served to intensify this public interest. In October 1881, two years after The Ottawa Field-Naturalists' Club was founded, one of Canada's most remarkable landslides took place on the Thompson River in British Columbia, near the small town of Ashcroft. Terraces above the incised river valley were being irrigated with water from the mountains above, impounded by amateur-built dams. One of these failed. Resulting seepage through the steep slope above the river and the new railway track caused a slope failure which precipitated 60 million yd^3 (45×10^6 m^3) of soil and rock into the river, blocking its flow completely. The artificial dam was 160 ft (48 m) high. Only when it was overtopped by the impounded river water was flow resumed downstream, initially with a mighty flood that it is difficult to imagine (Stanton 1897).

Twenty-two years later, on the morning of 29 April 1903, the great rock fall occurred at Frank, Alberta. This took 70 lives and buried well over 1 mi (1.6 km) of the Crow's Nest Railway (Report 1912). News of this disaster quickly reached eastern Canada, but there had been devastating local landslides which must have had even greater impact upon the public conscience. All were in the so-called Leda Clay, now better called the Champlain Clay, well known for its unusual sensitivity. In 1894 occurred the slide at St. Albons involving the rapid flow sliding of 600 million yd^3 (450×10^6 m^3); in 1895 that at St. Luc de Vincenne in which five lives were lost; and in 1898 another at St. Thuribe in which a mere 3.5 million yd^3 (2.7×10^6 m^3) moved. Almost in the outskirts of Ottawa, on the Lièvre River, occurred in 1908 the tragic slide at Notre Dame de la Salette in which 33 lives were lost (Mitchell and Markell 1974).

When, therefore, the headquarters of the Geological Survey of Canada (GSC) was moved from Montreal to Ottawa, few residents of this city had to be told what the science of geology was. The Survey had started its work in 1842 in Montreal as the one-man effort of William Logan. Under his inspired leadership it had grown in staff and activity, and had started its own museum. So well was its work appreciated that when the perfectly logical move to the capital city of Ottawa was proposed, the strongest objections were raised by Montrealers (Zaslow 1975).

It is wryly humorous today to read of the Director at the time, A. R. C. Selwyn, saying that "removal to Ottawa could not fail to operate in every respect most prejudicially." But the Geological Survey Bill was passed by Parliament in 1878 and the move was confirmed. Objections continued. Principal J. W. Dawson of McGill wrote personally to Sir John A. Macdonald. The Montreal Natural History Society objected strongly in 1881 and the Montreal Board of Trade went so far as to send a delegation to Ottawa in an attempt to stop the move. The transfer of staff, equipment, and museum collections was made, however, in April and May of that same year. Principal Dawson received a grant from the Redpath family to start a new museum at McGill. And when the Geological Survey Museum was reopened in Ottawa, it attracted 9549 visitors in its first year, as compared

with 1652 in its last operative year in Montreal, proof indeed of the well-developed interest here in natural history, and especially geology, 100 years ago.

The Geological Survey moved into the fine gray stone building still standing at the corner of Sussex Drive and George Street, adjacent to the market area. The building served originally as a hotel but had been extended and was refurbished for Survey use. Some members of the Survey staff worked there until 1959, an occupation of almost 80 yr: the Survey moved in that year to its own building on Booth Street. The old George Street building is, therefore, by far the oldest "scientific building" in Ottawa. Happily well preserved, should it not be today the headquarters for Ottawa's many scientific societies? In its day, it was the scene of many dramatic encounters, as all who know the history of our distinguished Survey will appreciate. Many famous geologists passed through its doors. Early members of The Ottawa Field-Naturalists' Club with geological interests must have been regular visitors, for it will have been observed that the Survey moved to Ottawa two years after the founding of the club. Throughout the club's history, therefore, those interested in this particular branch of natural history had available to them the possibility of association with professional geologists, with a geological museum and library. It is not surprising, therefore, to find geology occupying a prominent place in the early years of the club's activity.

Before glancing at this, however, that earlier reference to the Montreal Natural History Society may be noted. This society was founded in a small way in 1827 and by 1858 had its own spacious quarters and museum at the intersection of Cathcart and University streets. So well established was the society that it was one of the hosts when, in 1857, the American Association for the Advancement of Science held its annual meeting in Montreal. Sessions were held in the Court House, the Natural History Society tendering a soirée as a part of the social activities. Even older, however, was the Literary and Historical Society of Quebec, founded by that outstanding (but often misjudged) Governor, the ninth Earl of Dalhousie, the founder also, with John By, of our own city of Ottawa. In the first volume of the Quebec Society's journal, published in 1829, there were two papers on geology (Baddeley 1829; Bayfield 1829).

Down by the sea, the Nova Scotian Institute of Science was founded in 1862 by the amalgamation of the Halifax Mechanics' Institute (founded in 1830) and the Halifax Literary and Scientific Society (founded in 1839). The Nova Scotia Museum had its origin in the museum started by the Mechanics' Institute in 1831, a large proportion of the early exhibits being rocks, minerals, and fossils. The museum participated in the 1867 exhibition in Paris, under the leadership of its curator, the Reverend Dr. David Honeyman, the Presbyterian Minister at Arisaig, Halifax, who became an authority on the Silurian fossils of his area (R. Grantham, personal communication).

The Ottawa Field-Naturalists' Club had its antecedents also, mainly geological. As is well known, Ottawa had its origin as the main construction camp of the Corps of Royal Engineers when they came in 1826 to start the building of the Rideau Canal, selected by Lieutenant Colonel John By and approved, on the spot, by Lord Dalhousie. Named Bytown unofficially but in honor of the Superintending Engineer, Bytown it remained until the official change in name to Ottawa in 1855. It is difficult today to credit that even at that early date, less than 30 years after the first tree was cut in the unbroken forest, there was here an established Silurian Society. But Hunter recorded in his *Ottawa scenery,* published in 1855, that in the library of the Silurian Society he had seen "a small, but very beautiful illustrative collection of geological specimens; for this the people of Ottawa are mainly indebted to Mr. Billings . . ." (Hunter 1855). The original Natural History Society was formed in 1863 but in 1869 amalgamated with the Mechanics' Institute (founded originally in 1847) to form the Ottawa Literary and Scientific Society from which our club was an offshoot. All the bodies mentioned regularly had public lectures on geology.

There was, therefore, a well-established geological tradition in Ottawa when the club started its work, and so it is not surprising to find that geology looms large in the early records of the club. As we have been so pleasantly reminded in *Trail & Landscape,* by 1893 the club members had prepared a geological map of the Ottawa area (Reddoch 1979). Members assisted in the preparation of a report on the Stewart Quarry, near Rockland, which contributed to the settlement of a case before the Exchequer Court of Canada. The club advised the Ottawa Granite Company about a local outcrop of quartzite which led to successful use of this deposit. Geological field trips were frequent, quite a number being to sites within the limits of the city, owing to the state of the city's development at that time. A favorite location for the collection of fossils was "The Heap" south of Beaver Meadow, west of Hull, a pile of broken Trenton limestone excavated from the nearby railway cutting. Thirty specimens were obtained during a single visit in 1900.

With the Geological Survey now well established in Ottawa, with railway construction across the Dominion of Canada regularly bringing to light new facets of geology, and with occasional natural disasters providing

tragic reminders of geological hazards, it is small wonder that those early years saw a real flowering of geology as a major club activity. At the time of the club's formation, there was a lively interest in the geology of cities. In 1885, for example, there was published in Philadelphia a well-illustrated volume entitled *Town geology:* "the Lesson of the Philadelphia Rocks; Studies of Nature along the Highways and Byways of a Metropolitan Town," the author being Angelo Heilprin of the Academy of Natural Science of Philadelphia (Heilprin 1885). In England, there had been published another fine volume with exactly the same title, *Town geology,* in 1877 (by a publisher with the Dickensian name of Daldy, Isbister, and Company). The author was the Reverend Charles Kingsley, eminent Anglican divine who once visited Ottawa, better known, perhaps, as the author of *Westward ho!* and *The water babies* (Kingsley 1887).

There was no Canadian book with the same title, but in 1900 one of the most colorful presidents of this club, H. M. Ami, presented to the Royal Society of Canada a fascinating paper entitled "On the Geology of the Principal Cities of Eastern Canada." Ami pleaded for a continuing study of the geology beneath city streets for, as he said: "What the drill has to penetrate in any one of our larger centres of activity in Canada . . . is a question not only of interest but also of economic value" (Ami 1900). If only Canadian engineers had given heed to that sound advice, this country could today have been a world leader in the study and recording of urban geology. But as the young country hastened on its way, geology fell into neglect in engineering, just as it did in natural history circles.

Ami, a graduate of McGill, joined the staff of the Geological Survey in 1882. A palaeontologist of note, he must have made life a little difficult at times for his superiors. It is recorded of him that he was absent from his official duties for 284 working days in the space of four years. His wife was a lady of means and so he was able to undertake private ventures such as leading an excursion to the south of France to study cave remains of early man. Later, in Ottawa, he rented a room in a downtown building in which to display his finds. He resigned from the Survey in 1910 because of ill health. It would have been interesting to hear his pithy comments upon all the troubles that beset the new building into which the Survey moved its headquarters in that same year, 1910.

This was the Victoria Museum in which this meeting is being held. The very odd appearance of the front entrance is explained by the fact that the extension for the entrance hall was designed, and built, four full storeys in height, crowned by a magnificent castellated tower ("Victorian wedding-cake architecture at its worst" as it has been described). The contractor for the building warned that the heavy masonry walls would exert too great a bearing pressure on the foundation beds, but his warning was not heeded. Excessive settlement took place before the building was occupied. The front extension broke away from the rest of the building, and there was a gap (near the roof) of 14 in. (35 cm) when the contractor was ordered to remove the tower and the upper two storeys before complete failure occurred.

It was ironic that this classical failure should have taken place in the building erected to house the Geological Survey and its museum, since the cause of the trouble was geotechnical. By chance, the building was located on one of the "pockets" of Leda Clay that are features of the urban geology of Ottawa. The clay was loaded almost to the point of failure. Settlements were to be expected. Modern geotechnical studies have been correlated with the long-term records of settlement, which today is negligible (Crawford 1953). The interior of the building has been reconstructed so that the wild tales circulating around Ottawa for 60 years — about the building's imminent collapse, about the great fault beneath the building which was supposed to be the cause of the trouble (this, from an eminent hard-rock geologist!) — should now be set at rest for ever.

The building is, however, now known around the world in geotechnical circles as a classical near-failure. The excitement surrounding its construction and necessary alteration must have been a major topic of conversation at the time, and further evidence of the importance of applied geology. But the war which started in 1914 soon put all such local problems in the background of public thinking. Reconstruction during the 1920s followed the Armistice of 1918. The slow rebuilding of the economy in the 1930s followed the stock market boom and collapse. Then came the second World War, its termination coinciding with the end of the second third of the century being marked by these lectures. Just as the first third was full of geological excitement, so the second third witnessed a remarkable decline in public and private interest in the science.

Mineral prospecting continued unabated, in the inter-war years, a life-saver for many men in the years of depression. Some new mines were brought into production, notably the Eldorado uranium mine on Great Bear Lake and the gold mines on Lake Athabasca and Great Slave Lake. The Geological Survey was put under severe strain during the 1930s, even its official name disappeared at one time. But its work went on, its loyal staff continuing their work despite all difficulties. One name must be mentioned from those trying years, that of a great lady who was an ardent member of this club, the late Mrs. Forsey (mother of Senator Eugene Forsey). She joined the staff of the Survey in 1913 and served as its librarian from 1918 to 1941. Through all the difficult years,

the Survey library was a lighthouse of hope to all interested in the science and the best source of geological information in Canada. How Mrs. Forsey managed to keep the library operating to its usual high standard was one of the mysteries of those years, although I do know that she thought nothing of buying small items of office equipment with her own money if the economies of the time made official purchase difficult. I can testify to the kindness and helpfulness which she showed me, a young visitor from Montreal, when I came seeking information on my occasional visits to Ottawa.

Geological instruction continued at universities but under severe restrictions. None of these deterrents, however, explain the great decline in public interest in this branch of natural history. Confirmation of this subjective impression is given by even a cursory study of the club's own journal, *The Ottawa Naturalist* until 1919, and *The Canadian Field-Naturalist* thereafter, published throughout this long period as a monthly journal (until 1943). Early volumes carried at least two or three good geological papers, regular items of geological interest from around Ottawa and, at one time, even a summary of the summer program of the Geological Survey of Canada. In the third volume of *The Ottawa Naturalist* appears the first annual report of the geological branch of the club, and in the fourth there are even annual reports from two branches, those for geology and mineralogy, and for palaeontology. The Geological Branch was still reporting in 1912. A third of a century later almost all references to geology had disappeared, only one or two occasional papers on fossils appearing, and this, despite the long and loyal service of Fred J. Alcock as Associate Editor for Geology.

There must be an explanation for this significant change which seems to be worthy of detailed study, rather than the necessarily brief survey made for this lecture. Such study as has been made convinces me that the blame must be attributed to high-school education. Once science was introduced into school curricula, chemistry, physics, and biology in some way unknown to me got priority of treatment. A good case can be made for the suggestion that geology, the science of the world around us, should be the first science to which young minds are introduced. Its study leads logically into the study of biology, of chemistry, and even of physics. But it did not receive this recognition. Even today, it is rare indeed to find any course on earth science, as such, in the curriculum of any North American high school. It is sometimes said to be included in more general courses such as those on social studies, or geography, but I am firmly of the opinion that a good introductory course in geology has a rightful place in the science curricula of all high schools, not only as the best of all introductions to science but also as a liberal influence in itself. As but one example of this continuing neglect, the Ontario Department of Education produced in 1971 a beautifully printed brochure of 36 pages describing a new course on urban studies in which the word geology does not appear once!

Despite this official neglect, there are some encouraging signs. There are many devoted teachers who do appreciate the value and interest of geology for young minds and who are teaching it in their classes. The American Geological Institute has had a major program related to high-school teaching and has produced much valuable material for teaching aids. In Canada, Professor Gordon Winder initiated a fine summer training course for interested high-school teachers, receiving support from industry for this effort at the University of Western Ontario. Similar courses are now available in other places, so the tide may be turning and we may yet see geology again recognized as an important part of natural history.

It is significant to note that the Geological Association of Canada (GAC) was not started until 1947. Prior to that the only national meeting place for professional geologists was at the small annual meetings of the Royal Society of Canada (to which, incidentally, this club used regularly to send a delegate). The exclusive membership of the Royal Society, junior to this club by four years, meant that younger geologists had to turn to British or United States journals as outlets for their writings. Today the GAC has a membership of about 3000 and two regular publications that supplement the *Canadian Journal of Earth Sciences,* published by the National Research Council, which has already made its mark, in its 15 yr, as one of the leading geological journals of the English-speaking world.

On the more general front there has been the welcome establishment of many local groups of "Rock Hounds." I use the colloquial expression to indicate, with appreciation, the many clubs in Canada today of mineral and rock collectors and gem fanciers, almost all of which are of post-war origin. One of the few exceptions is the Walker Mineralogical Club associated with the University of Toronto, with its own distinguished publication.

One of the post-war turning points, I feel sure, was the series of popular lectures on geology delivered over the national radio network of the CBC in the late 1950s by David Baird and his later lectures on television. The radio lectures were reprinted as an attractive booklet. In both spoken and written form these excellent presentations must have awakened the interest of many Canadians to the fascination of geology. Baird followed up his radio and television talks with his series of pocket guides, first (in 1960) with *A guide to geology for visitors in Canada's national parks*, which is a booklet of use and value anywhere in Canada (Baird 1960). In the same year

the Geological Survey published *The story of the mountains in Banff National Park* by Helen Belyea, also in pocket form (Belyea 1960). In succeeding years a series of similar guides by Baird to the geology and scenery of all the major national parks (and the National Capital District) were published, so successful that some have been reprinted by a private publisher in association with the Geological Survey. W. H. Mathews of the University of British Columbia has written, and the GAC has published *A popular guide to the geology of the Garibaldi Lake area,* that wonderful playground for residents of Vancouver (Mathews 1975).

Many of the regular publications and maps of the Geological Survey are naturally of use to amateur geologists. Special mention, however, must be made of the 16 guides to *Rocks and minerals for the collector* written by Ann Sabina of the Survey staff, some in association with joint authors (Sabine 1963). The first four gave general coverage for the whole country, subsequent guides being for specific areas. The Survey is also responsible for the distribution of the 87 guide books that comprise the series prepared for the Twenty-third International Geological Congress held in Canada in 1972. The tours arranged for participants in this great gathering covered the country from the High Arctic to the southern tip of Ontario; so do the guide books. Copies are still available, still in regular demand; and a list is available from the Survey. We now have a special highway map for Ontario showing the main features of the geology of the province. And suites of minerals and rocks are readily available, about 6000 sets being sold every year to prospectors and amateur geologists. There is, therefore, a wealth of information about the geology of all parts of Canada readily available in convenient form for purse or pocket for the use of all who travel and who want to do more than just admire the scenery.

For those who dwell in cities and are limited in the traveling they can do, there are now available, from coast to coast, museums, large and small and of varying degrees of excellence, almost all with geological exhibits. After the museum in this building, pride of place must be given to the Royal Ontario Museum, established in 1914, which now has one of the world's leading mineralogical collections, having specimens of about 1800 of the 2400 minerals now known. It has also one of the few original copies of William Smith's geological map of England and Wales. Its appreciation of the interests of the average citizen was well shown during the construction of the first section of the Toronto subway when a special exhibit was arranged showing the geological strata encountered in excavation for the subway beneath the streets of the city, and the methods followed in excavation, with actual samples of the rocks and soils encountered.

From the many other museums, large and small, two have been of special attraction. At Drumheller, Alberta, I was surprised to find a most excellent display of the local geology in the local museum, including a complete skeleton of one of the dinosaurs (the first I believe) excavated in the valley of the Red Deer River. On the other side of the country is the island of Grand Manan, guardian of the entrance to the Bay of Fundy. A small island, 15×7 mi (24.1×11.3 km), with a population of less than 3000, it yet has a fine little museum, established by the islanders in 1967 as a centennial project. It, too, has a first-class exhibit of the island's geology owing, largely, to the enthusiasm of the "naturalist-extraordinary" of the island, Elmer Wilcox, to whom the whole realm of nature is an open book.

There are books, too, about the geology beneath the streets of some Canadian cities, not very many as yet but some of which I know are exemplars of what every city in Canada should have. G. H. Eisbacher of the Geological Survey has written, and again GAC has published, *Vancouver geology*, a popular guide to the geology of Vancouver (Eisbacher, 1977). The "Saskatoon Folio" is now justly famous far beyond the borders of Canada (Christiansen 1970). Toronto has, to date, only a well-produced leaflet about its geology, and Montreal a splendid, but professional, 244-page official report, not easy reading for the amateur (Clark 1972). Ottawa has been here in the lead, thanks to the publications of this club.

In 1962, *The Canadian Field-Naturalist* published as a special feature, and the club later reprinted, a splendid "Guide to the geology of the Gatineau-Lièvre district" by Donald Hogarth, one of the best guides of its kind known to me (Hogarth 1962). Hogarth has continued his studies of minerals and mining on the "other side of the river," one product being his delightful booklet on "Pioneer mines of the Gatineau region, Quebec" (Hogarth 1975).

The best of all I have kept to the last so that I may conclude with my tribute to one of the greatest ladies I have ever been privileged to know, Alice Wilson. There is no need for me to remind this audience of her many distinctions, of her long membership of this club, covering half of our century, of her devoted service to the Geological Survey continuing, quite unofficially, until her 80th year. But I would remind you that in 1956 *The Canadian Field-Naturalist* published a special monograph issue (and later reprinted) "A guide to the geology of the Ottawa district, by A. E. Wilson (Wilson 1956). Its writing was a labor of love, as you can tell when reading it, but one had to be with her in the field to realize the way in which she could make any aspect of geology interesting and arresting. She indeed knew, and showed in so many ways that geology is, in Charles Kingsley's

phrase, *The people's science*. So should it be thought of today; so must it be thought of if we are to be true guardians of the heritage that is ours in this land of Canada.

Knowing Alice Wilson as I did, I feel sure that she would have agreed that the best way to bring to a close this brief review would be for me to use not my own words, but rather the words which Charles Kingsley used to end *Town geology* almost exactly 100 years ago;

> If I shall have awakened any townsmen here and there to think seriously of the complexity, the antiquity, the grandeur, the true poetry, of the commonest objects around them, even the stones beneath their feet . . . if I shall have helped to open their eyes that they may see, and their ears that they may hear, the great book which is free to all alike, to peasant as to peer, to men of business as to men of science, even that great book of nature which is, as Lord Bacon said of old, the Word of God revealed in facts, then I shall have a fresh reason for loving that science of geology, which has been my favourite study since I was a boy.

Acknowledgments

I gratefully acknowledge the provision of information by the following: A. Baracos, R. Grantham, H. R. Gulliver, P. Harker, and D. C. Tibbetts; in addition to that provided by the books referenced and, in some case, by their authors.

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Federal Wildlife Conservation Work in Canada in the Past 100 Years[1]

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North America was discovered by Europeans who sought the riches of the East Indies. Having encountered Canada they found that there were great resources there of fish, trees, and fur. They began the harvest of those resources and transported the products to the markets of Europe. Beaver became symbolic of Canada because its pelt was one of the first export products to Europe. Wildlife was important from the beginning of Canada. Most of the people carrying out the exploitation of the resources came from Europe and to them the stocks available in North America seemed almost without limit. That tradition of abundance lasted for a long time and indeed still persists in parts of Canada.

As Canada became settled and heavy use was made of wildlife in small areas, game laws were introduced and have been in effect in parts of Canada since the early 1700s. At the time the provinces were united under the British North America Act, provincial control of wildlife resources was well established and there was little federal concern. In fact the whole matter was taken so much for granted that there is no mention of wildlife in the British North America Act.

That did not indicate a complete lack of federal interest, however, because there were some federal activities on behalf of wildlife as early as 1887 when the islands and shoreline at the north end of Last Mountain Lake, Saskatchewan, were created a bird sanctuary by Order-in-Council on 8 June 1887. That was one of the first activities of the kind in North America. On 23 June 1887 Canada's first national park was authorized under the Rocky Mountain Park Act. There were clauses in that legislation relating to wildlife protection, but the main intent was the creation of a tourist resort and the preservation of a group of hot springs and associated scenery rather than the management of wildlife. As the parks organization expanded, progressively more attention was paid to wildlife, but most national parks were created primarily to preserve other values.

On 12 May 1909 a bill to establish a Commission of Conservation in Canada was passed in Parliament. That Commission, in which both federal and provincial officials participated, was nonpartisan. It was a unique, autonomous, objective body set up to explore questions pertaining to natural resource conservation in Canada. It was set up to be responsible directly to Parliament and was so arranged that it would report to the House of Commons from time to time through the Minister of Agriculture although it was not responsible to him or to any other minister or government department. The Commission could deal with any and all resources and as such had many responsibilities beyond those involved in wildlife and related renewable resources. The Commission kept in touch with a rather similar organization in the United States and considered international concerns as well as those affecting Canada alone. Among the early projects undertaken by the Commission were an analysis of fishery resources in Canada, a compilation of statistics on commercial fishing, and summaries of dominion and provincial laws and regulations governing fisheries with special reference to the oyster and lobster industries. A paper on fur-bearing animals and how to prevent their extinction was considered in 1910. That was mainly aimed at the fur-trapping industry. The fur trade, like the fisheries, was a major industry in Canada at that time. There were also considerations of fur farming which was just beginning to develop. During the first three years of the Commission's work, most of the studies involved the economics of fish and fur-bearing animals. The emphasis was on utilization rather than conservation. An investigation in 1921 suggested that the Commissions work overlapped that done by other government agencies. During the period of Commission, its pioneering activities had come to be well done by government agencies in forestry, water power, agriculture, interior, marine and fisheries, mines, publicity, and external affairs. Wildlife was not included in the resources listed in that review, possibly because the review committee was not particularly interested in wildlife. The Commission ceased operations in 1921 after 11 years of activity during which it had helped to encourage public interest in wildlife and conservation and the development of public sentiment in favor of that activity.

Between 1850 and 1900 a number of influential persons in North America had become concerned about the declining supplies of Passenger Pigeons and Bison. When they looked ahead they could see the end of certain species unless actions were taken to prevent it. One group of birds of concern to many people was waterfowl including ducks, geese, and swans. They were shot for food and for sport and indeed were a part of the

[1]This paper was presented on 19 May 1979 at The Ottawa Field-Naturalists' Club Centennial Symposium entitled *100 Years of natural history in Canada.*

commercial food supply in many parts of the country. Although provinces and states had been legislating for the protection of wildlife for more than 100 years, they found that they could not effectively deal with a migratory resource like waterfowl that moves from the breeding grounds to the winter grounds in the fall and returns in the spring, and is harvested in each jurisdiction through which it passes. In that situation it is easy to overharvest the stock. Not only the annual increment was being taken each year but a part of the parent stock as well. There was also shooting in the spring and on the breeding grounds which was very destructive of the resource. Farsighted people then tried to have the harvest reduced by encouraging the provinces and states to cooperate. That was easy to suggest. Human nature being what it is, it was very difficult to bring about. When the birds were in a province or state, that province or state tried to secure the best possible opportunity for its citizens to harvest a "fair" share of the resource, knowing that other political entities would also be involved in the total amount of the harvest. Invariably each political entity took its full share of the harvest and perhaps a bit more, and the decline continued.

There was an attempt in the United States to impose federal control on the system, but that was challenged by some states as unconstitutional and the whole matter was referred to the United States Supreme Court. It was clear that federal control in that way was unconstitutional in the United States and that a similar attempt in Canada would probably be unsuccessful for similar reasons. Farsighted people in Canada and the United States sought a solution that would be acceptable and workable in both countries. The solution they finally arrived at involved a treaty between the two countries. It worked simply because in both the British North America Act and the United States Constitution there is provision for the implementation of the terms of an international treaty as a federal responsibility.

After several years of preparatory work the Migratory Birds Convention (Treaty) between Canada, represented by Great Britain and the United States, was signed in 1916. Following that, each country passed legislation implementing the treaty and began to promulgate regulations for the control of the migratory birds referred to in the treaty. The signing of the treaty, and of the act based upon it, put the federal government squarely into the wildlife management business for the first time.

There was created, by Order-in-Council on 28 December 1916, an Advisory Board on Wildlife Protection. That organization had been recommended by J. B. Harkin, the Commissioner of Dominion Parks, and had as its members James White, D. C. Hewitt, R. M. Anderson, as well as J. B. Harkin. One of the first jobs that members of the Board did was to draft the Migratory Birds Convention Act and suggest the appointment of an officer to administer the act and regulations. They also drafted a Northwest Game Act and concerned themselves with Caribou in the Northwest Territories, Pronghorn, Elk, wolves, and other wildlife, as well as special habitats such as Point Pelee and Bonaventure Island and a number of areas of importance for birds in western Canada.

Because of the passage of the Migratory Birds Convention Act, there was a need for an official to be appointed to carry out the terms of the act. By 1918 there was an active and growing National Parks organization in the Department of the Interior. It seemed logical that an agency dealing with wildlife should be located within the National Parks organization. Accordingly the official charged with responsibility for the Migratory Birds Convention Act, Hoyes Lloyd, reported for duty to that agency on 11 December 1918. His job was called Ornithologist and he started at a yearly salary of $2200. His basic responsibility was administration of the Migratory Birds Convention Act, but he had an added responsibility involving the Northwest Game Act as well. In 1919 the protection of wildlife in national parks was added to his duties and his title was changed to Supervisor of Wildlife Protection. He had a secretary and, as you can imagine, he and the secretary were kept pretty busy trying to cope with migratory birds and their problems throughout Canada, game in the Northwest Territories, and wildlife in national parks. It was not long before he was able to convince his superior, J. B. Harkin of the National Parks Branch, that he needed some help to carry out a job that covered such a large area and involved so many wild creatures of a wide range of species.

His pleas for assistance in carrying out his duties as Superintendent of Wildlife Protection resulted in the creation of additional positions in the summer of 1920. Competitions were held for the positions of Chief Federal Migratory Bird Officer for Ontario and Quebec, and for the western provinces. J. A. Munro of British Columbia was the successful applicant for the western position and Harrison F. Lewis for the position involving Ontario and Quebec. Prior to the appointments for migratory bird officers for western Canada and for Ontario and Quebec, R. W. Tuffs of Wolfville, Nova Scotia, was appointed on 19 November 1919 as officer for the maritime provinces.

As can be seen from the record thus far, although the Commission on Conservation had functioned since 1911 and an advisory board on Wildlife Protection since late 1916, work by qualified professionals in wildlife

conservation did not begin in the federal government until 1920 and only then because of the responsibilities under the Migratory Birds Convention. As the years passed, there were further subdivisions of Canada in terms of staffing in the federal service, and eventually J. A. Munro restricted his activities to British Columbia and J. Dewey Soper came on strength to deal with migratory bird problems in the prairie provinces.

By Order-in-Council on 12 April 1921, H. Lloyd was appointed Secretary to the Advisory Board on Wildlife Protection to ensure that his work as Superintendent of Wildlife Protection would be fully coordinated with that of the Advisory Board. The Advisory Board continued until the late 1940s and always had as members or secretary, members of the organization which began with the appointment of H. Lloyd.

As the little nucleus of wildlife officials expanded within the National Parks organization, their assistance was frequently requested on behalf of wildlife in the national parks and in the Northwest and Yukon Territories. Although the basic responsibility was and remains migratory birds, the other responsibilities increased with time. By the late 1930s there was added staff with expertise in matters involving mammals and freshwater biology including fisheries, with particular reference to the fishery resources of the national parks. After 1945 the mammal and freshwater activities were expanded. By 1947 there were three mammalogists, a limnologist, the four chief federal migratory bird officers, and the Superintendent of Wildlife Protection with supporting staff. At that point the Director of the Lands, Parks and Forests Branch of the Department of Mines and Resources deemed that a separate federal wildlife agency should be created. The Dominion Wildlife Service came into being in November 1947. It became the Canadian Wildlife Service in April 1950.

Starting with the Commission of Conservation which involved the provincial governments as well as federal government officials, there was a tradition of increasing federal and provincial cooperation in the wildlife field. With termination of the work of the Commission of Conservation and the need for close cooperation with regard to migratory birds conservation, a series of conferences was begun in 1922 at which federal and provincial officials came together. They discussed migratory birds and the differing approaches to the use, conservation, and control of those resources by the two levels of government. They also dealt with other matters of interest to both federal and provincial wildlife officials. The Federal–Provincial Wildlife Conferences which began in 1922 were held initially at irregular intervals but eventually became annual fora for the exchange of ideas throughout the wildlife field; the one held in July 1978 was the 42nd in the series. Over the years those conferences have been extremely helpful in sorting out the differing approaches to wildlife conservation when perceived from the federal and from the provincial points of view. As a case in point, which has been debated frequently, the federal government, under the Migratoryework of the Migratory Birds Convention Act and Regulations, is responsible for safegarding the migratory bird resources by whatever means are appropriate. Provincial governments on the other hand look upon migratory birds as resources which pass through their jurisdictions annually, which are harvested by their citizens, and from which, through the sale of licenses and other means, they secure revenue for operating at least a part of their wildlife management activities. Because of the differences in approach there are annual discussions about what harvests of the harvestable resources should be allowed and under what conditions. Because federal and provincial officials cooperate in annual studies of the resources, there is usually no argument about the data on populations and distribution which are the key to decisions about allowable harvest and where, when, and by what means it should be conducted. There are complicating factors, including those related to the damage which migratory birds may do to agricultural crops largely as a result of the kinds of technology used in harvesting those crops. To put it bluntly the grain farmers would like to see fewer ducks. The duck hunters would like to see more, and the provincial and federal governments are in the middle of the perennial debate about how many there should be and where they should occur. Enforcement of provincial and federal regulations regarding the harvest of waterfowl by hunters is carried on jointly by the Royal Canadian Mounted Police and the provincial conservation officers.

The major responsibility of the forerunner of the Canadian Wildlife Service was migratory birds and the service still has that major responsibility. Over the years through cooperation with provincial governments and private industry, the Canadian Wildlife Service has become involved in a variety of other projects ranging from the controlled reproduction of raptors to prevent extinction of such birds as Peregrine Falcons, through studies of animal diseases which are sometimes very important both to wildlife and to humans (for example rabies), and in recent years increasing involvement with toxic substances in the environment. Those substances, in all parts of Canada, may have detrimental effects on migratory birds and in many cases on fish and other wildlife and on people.

Cooperation has always been good between the federal Canadian Wildlife Service and its provincial counterparts and with other agencies in wildlife work including those in the private sector of the economy. Cooperative studies of joint importance have gone on for more than 30 years. To bring a measure of legislative

authority to such arrangements Parliament passed the Canada Wildlife Act in July 1973. This made it easier to justify to the Treasury Board expenditures for cooperative work with provinces which in any case had been going on for a very long time. It has one rather unique feature in that it defines wildlife as any non-domestic animal. With that definition, it can deal with any kind of wildlife in the country. The new act has not yet resulted in research on the well-being of frogs or snails or some of our smaller invertebrate friends, but it looks as if there is the authority to do just that if there is ever need for it.

Federal activity in the wildlife field naturally brought the Canadian Wildlife Service into contact with the original Canadians. Many of the treaties that were signed between the Government of Canada and the Indian tribes talk about the right of access to wildlife. When the Migratory Birds Treaty was signed it set limits on when migratory birds could be taken. Applied to native populations in remote areas, those would have created hardships and real difficulty. The application of those regulations had to be tempered with the reality of human survival and so it was for many years. With the rise in concern over native rights in recent years, the native land claims settlements in the James Bay area, and those under negotiation in the Mackenzie Valley and other parts of northern Canada, it is probable that native use of migratory birds will come under a different sort of control. It may be necessary to modify the Migratory Birds Treaty to spell out more clearly the application of the act based on that treaty to native peoples throughout Canada. That matter is under study.

Public reaction to wildlife as shown by federal government action has changed from a complete lack of concern for supposedly infinite stocks 100 years ago to great concern for wildlife and its habitat now. Canadians currently examine the potential impact on wildlife and its habitat of almost any large construction project proposed. The recent development of public awareness of the worth of wildlife resources now seems to assure wildlife a continuing place in the Canadian way of life.

When the world human population reaches a sufficiently high level, decisions will have to be made between using land for production of human food and for the production of wildlife. Then there will be very many hungry persons who will not opt for the presevation of wildlife habitat. Nevertheless, until we in this fortunate country reach that unhappy state of affairs, there will be ample land not required for food production. Wildlife if properly managed can be produced and can continue to offer to Canadian citizens and their guests all of the rewards which we normally associate with being able to observe, photograph, and harvest wildlife resources.

We have had an almost complete reversal of public attitude to wildlife during the life of The Ottawa Field-Naturalists' Club. It is interesting to realize that many people who were instrumental in creating the agencies I have discussed were, at the same time, active and productive members of the club. In the early years, only a small, dedicated minority was concerned with wildlife; now, governments at all levels are well aware that tourism, based on an interest in wildlife and the out-of-doors, is one of the two or three largest earners of foreign currency for Canada. Those who came together 100 years ago to form the club and to foster their interests in wildlife and to encourage the public to become interested in wildlife have been well rewarded for their interest and foresight.

Man evolved as a hunter. Hunters had to know a lot about wildlife to be successful. Although we no longer must kill wildlife to survive, we are still hunters. As hunters and naturalists we find it rewarding to know where to find wildlife, how to observe it, and how to pass along our knowledge and capacity for outdoor pleasure to succeeding generations.

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A Canadian Paradox — Private Land, Public Wildlife: Can it be Resolved?[1]

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In Canada wildlife is the sole resource that remains legally the property of the Crown, even on lands that are privately owned. As a consequence, wildlife as a resource has traditionally been viewed as expendable whenever it competed with any other resource that was the property of the landowner. In a recent discussion of this problem in the United States, Davis (1979) concluded that "[in] the United States where approximately 2/3 of the land area is owned by the private sector, wildlife is considered not as an economically competitive resource but merely as a nonessential by-product" and that "[competing] uses for land have been and continue to be one of the most important influences on the survival of America's wildlife resources which include all life forms not dependent upon man for survival."

It is not our function to attempt to resolve definitively the problems of just exactly what "wildlife" is. There are numerous definitions that have historically included only those animals that are in one way or another harvested by man both for economic and recreational return. Plants are not usually thought of as wildlife and, until recently, neither were the terrestrial cold-blooded vertebrates and invertebrates (Clarke 1974). Because we feel that an abundance of wildlife has other than future consumer interests and benefits, our working definition will be *any undomesticated plant or animal.*

Today, throughout much of the settled regions of the prairie provinces of Canada, those modern agricultural practices, inimical to the survival of wildlife populations which historically inhabited those regions, are often encouraged by governmental and agricultural agencies. Even on land held in the name of the Crown, wildlife resources, for the most part, are not given priority or even parity with other resources that have immediate commercial value, such as forest production or open cattle grazing. Such disregard for wildlife has a long history in Canada. Except for fisheries, the wildlife resource is not mentioned specifically in the British North America Act of 1867. The resource automatically and without challenge became a provincial and territorial responsibility until a federal involvement was established in 1917 with the passing of the Migratory Bird Convention Act and the National Wildlife Policy and Program in 1966. The former guaranteed protection to migratory game birds as well as a large number of nongame species; the latter authorized the Canadian Wildlife Service to acquire and manage wildlife habitats known as National Wildlife Areas, and to take responsibility for all types of wildlife in national parks and in provinces and territories where the interests of wildlife species surpassed the boundaries of such provinces and territories. All Canadian provinces and territories have their own wildlife agencies and programs, the main thrust of their operations being to manage the wildlife resource, primarily but not solely, from a consumptive viewpoint.

Thus, although we have created in this country, federal, provincial, and territorial agencies whose mandate it is to conserve and manage wildlife, those actually responsible for administering the policies that deal with the resource find themselves in a paradoxical situation. They must attempt to conserve and manage wildlife, yet they have only very limited jurisdiction over the habitat upon which the resource is wholly dependent. If we are to succeed in assuring a future abundance of wildlife, it is imperative that those charged with managing and conserving the resource have more say in the formulation of land use policy both on privately owned lands and those held in the name of the Crown.

To realize the goal of future wildlife resource abundance, we believe there must be some incentive for the landowner to retain wildlife habitat. Perhaps the right of the private landowners to receive compensation or even profit for providing or enhancing wildlife habitat should be recognized by all sectors of Canadian society.

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[1]This statement was written as background for an ongoing discussion within the Wildlife Biologists' Section of the Canadian Society of Zoologists. It was prompted by a growing concern among biologists over the loss of wildlife habitat in the more populated parts of Canada, expressed most effectively for the continent as a whole in A. J. Leopold's recent book *The California Quail* (1978. University of California Press, Berkeley).

Here we look at some possible ways and means of accomplishing, for the private landowner, some form of financial return for retaining viable wildlife habitat in areas where economically important biological resources other than wildlife currently form the livelihood for the landowner.

The lack of tradition and incentives for the establishment of wildlife areas on private land represents a very serious historical omission in Canada. There exists no pride in owning, or encouragement to establish, wildlife habitat. Within the prime agricultural areas of Alberta, Saskatchewan, and Manitoba, there are two main classifications of agricultural crop lands: unimproved and improved. Improved land consists largely of cropland given over to cereal grains. Unimproved land is, in the main, range pasture, i.e., grazing lands with natural vegetation, copses, potholes, and streams. The Dominion Bureau of Statistics (1968) and Statistics Canada (1978) documented the areas of these lands in the three prairie provinces. Between 1961 and 1976 the total area of improved land increased by 37 316 km^2 (13 434 mi^2) through conversion of unimproved land on old holdings as well as clearing land on new holdings.

On the prairie provinces it is the conversion of land from the unimproved to the improved status that, in many ways, is the root cause of the existing paradox. Under the present regulations the Canadian Wheat Board markets all wheat, oats, and barley delivered to them by the producers, but takes no responsibility in the area of land-use policies. Each producer obtains a permit to deliver a given quota of the above crops, depending on the area of improved land under his control. The quota system provides for all areas not cultivated in quota crops (for example, field peas, sunflowers, mustard, sugar beets and potatoes, summer fallow, nonnative pasture, and new breaking) to be transferred to the actual crop area. Area in perennial forage, up to a maximum of one-third the actual crop area, is also transferable to the quota area. The result is to increase the quota that can be marketed. The upshot of this system is that it prevents a farmer from claiming unimproved land in establishing his delivery quota. By simply tilling his unimproved land, the farmer can include it in his crop area entitlement and thus potentially realize increased financial return.

The Canadian land assessment regulations automatically place a tax value on all unimproved land and so-called wasteland. Section 30 of the Canadian Income Tax Act (1978) reads ". . . there may be deducted in computing a taxpayer's income for a taxation year from a farming business any amount paid by him in the year for clearing land, levelling land or laying tile drainage for the purposes of carrying on the farming business." Section 18(2)e states in effect that no deduction shall be made in respect of land that cannot reasonably be considered to have been in that year "held primarily for the purpose of gaining or producing income of the taxpayer from the land for that year."

The consequences of the Wheat Board and Income Tax regulations are that unimproved land cannot contribute to raising a farmer's crop quota nor can it be claimed for income tax purposes; in sum, it potentially costs the farmer money to leave as is. Sawatzky (1979) noted that this system of agricultural regulations creates among most farmers the opinion that they are paying taxes on land, the natural products of which are of little if any value to them. The result is that the landowner has no incentive to retain his unimproved land in its native state and, in fact, the incentive may be to improve his "wasteland" to realize some return on the taxes he pays out annually on it.

There are several ways in which farmers expend energy and money to improve their wasteland. All are detrimental to wildlife and include the following: intensive cultivation of lands that are marginal for agricultural production; summer fallowing which reduces soil fertility and tilth, increases soil vulnerability to wind and water erosion, and leaves a large area of our arable land in a state that is virtually uninhabitable by wildlife; draining wetlands which removes wildlife habitat and seriously influences groundwater systems and runoff patterns (Sawatzky 1979).

In most areas the above practices render no benefit to the surrounding lands *per se* (Miller 1979a, Sawatzky 1979), and in fact can cause deleterious effects particularly related to downhill erosion problems, changed soil chemistry rendering soils potentially sterile, and lowered water-holding capacity rendering low-lying land subject to flooding. Such practices are carried out mostly on lands of less-productive soil types with a poorer potential crop return. It appears that farmers who consider the costs, in terms of energy, time, and money, are more than compensated for by the current income tax laws and grain quota systems. Sawatzky (1979) detailed the needless practice of land "improvement" from a land management standpoint. Miller (1979b) noted that only half of United States landowners contacted have participated in voluntary conservation programs and of those only a few have adopted and retained all of the recommended soil conservation measures. The basic reason for a general lack of cooperation is clearly stated by Elderkin (1979); "It is not that farmers and ranchers are against wildlife, on the contrary the vast majority enjoy wildlife and are avid hunters. But they are in the business to make money and land not producing a cash crop is losing them money."

What then can be done to alleviate these problems? A modification of the regulations of the Canadian Wheat Board Act to permit transfer of unimproved land into quota entitlement would seem an obvious first step. The actual amount transferred should be tied to its utility for wildlife populations and this will depend on its extent and its quality. The farmer would then be able to claim such an area in his quota and at the same time he would not be required to expend energy, time, or money to maintain the land.

Second, the Canadian Income Tax Act (Section 30) should be modified to allow deduction for land that is significantly improved for wildlife and no taxes levied or deductions allowed for land that is left untouched or on which no significant improvements for wildlife have been made. Deductions are envisioned as all costs for improving the habitat in any given tax year. Additionally, we propose that Section 18(2)e of the Tax Act be changed to allow freedom from tax any land not held primarily for the purpose of gaining or producing income from a crop. We suggest that if direct income is obtained from the unimproved lands (see below), that such income be taxable and not based on area or owned property. It is conceivable that if no funds are received from unimproved land that no taxes should be levied, as long as the land has received some form of wildlife capability rating, perhaps along the lines of the Agricultural and Rural Development Act (ARDA) of 1961. Taxes currently levied on unimproved land, which would be lost to the municipality under the suggested scheme, could be recouped through an increased level of taxation on the cultivated portion of property where the bulk of income is attained in any one tax year. Arnolds and Woods (1979) discussed a unique program of direct financial and tax relief for landowners in Colorado which involved selling or giving a conservation easement to a portion of land whereby the owner may continue his farming or ranching operations and at the same time receive either cash for the rights that he sells or an income tax deduction for the value of the rights given as a qualified charitable donation. A state or federal agency or conservation group may acquire the recreational right to use the land for a cash price much lower than it would cost to buy outright. In Colorado annual taxation on the land subject to a conservation easement is assessed with regard to the restrictions on the use of the property caused by the easement. Thus the owner who sells a conservation easement could have his land revalued down and therefore pay lower property taxes. In effect the landowner receives two forms of financial compensation: one from the sale of some rights to his land and the second from lowered property tax. The people of Colorado have benefited significantly because at a moderate cost to the state they have the guarantee that the beauty of and accessibility to land will be preserved for the future. This system might work well in Canada.

Third, the establishment of a recognized legal fee schedule for both the nonconsumptive and consumptive use of wildlife should be considered. Most provinces neither authorize nor prohibit landowners from charging trespass fees for access to wildlife. Only Saskatchewan and Alberta specifically prohibit such payments under their Game Act and Wildlife Act, respectively (Thompson and Lucas 1973). Such fees should be permitted by law and payable in one form or another to the landowner for specified uses of habitat untouched, maintained, or improved for wildlife, in any given tax year. The fee structure established should reflect the value of the land for wildlife to encourage ultimately the landowner to develop attractive wildlife areas. However, if the landowners decide not to touch their lands and these lands have wildlife capability, there shall be no additional tax burden.

This suggested fee system runs counter to the philosophy in Canada that wildlife resources are free (Gottschalk 1977). However, Gottschalk (1977) noted that "[free] hunting is a bankrupt concept that prevents any but an intangible return on lands devoted to wildlife habitat." The landowner, unless he is totally motivated by esthetic considerations, bears the burden of wildlife habitat ownership with little or no compensation. Indeed, if wildlife habitat is attractive to large numbers of citizens, who frequently trespass on private land in pursuit of wildlife, whether birdwatchers, naturalists, hunters, or hikers, the maintenance of that habitat becomes a significant burden for the landowner.

Charges, especially for access of naturalists to wildlife sanctuaries and for hunting, are not novel. A number of states have established programs and fee structures for access to wildlife resources. In New Jersey, for example, the Green Acres Tax Exemption Program makes private land available for public recreation and nature observation with real estate tax relief to the landowner. In Nebraska the legislature has approved a $7.50 Habitat Stamp that is paid when a hunting licence is purchased by hunters (Gottschalk 1977). Funds from the stamp are used to improve privately owned land for wildlife. This fund does not assure hunter access; the decision to permit hunting rests with the landowner. If the landowner elects to permit hunter access, the Game and Parks Commission is authorized to pay him $2.50 per acre for this access. In California, specific fees have been established for access to private land, and are payable to the landowner depending on the type of services received or game hunted (Teague 1971). Although trespass fees, which mean direct reimbursement to the landowner for the right of access to wildlife habitat, is a growing practice in most provinces, payments received

by the landowner are not established by legislation and recognized as a legal source of income. Appropriate changes in the existing Acts could easily legalize these procedures. Fees paid for the nonconsumptive and consumptive use of wildlife could easily be administered through municipal or district game offices. Specific land permits would be purchased by each user, giving him access to the private land. Monies received by sale of the permits could then go back to maintain or develop land for wildlife conservation. Additionally, registration of land for access would be prerequisite for tax relief and crop quota. Such a system would not force landowners to permit persons on their land. Those that choose to prohibit access would still register their land as a wildlife area, for the Tax and Wheat Board benefits. Those individuals who wish to use the wildlife on their land would be entitled to receive additional financial compensation for continued improvement and repair of the habitat and possible restocking of the resource. Such a system would not penalize the landowner who has a fine habitat and who wishes to retain it in complete privacy. The system would cost little in energy and financial output to the individual and would positively encourage the maintenance of areas suitable for wildlife instead of destroying them for limited financial gain under the present legislation.

The above proposals are meant to stimulate ideas on solving the Canadian Wildlife Paradox. They will have to be discussed in depth to evolve mechanisms that are workable and satisfactory to almost all concerned, especially the wildlife resource. To this end we solicit the readers' reactions to these proposals in the hope that their responses will contribute to solving this important conservation problem in Canada.

Acknowledgments

We thank those personnel from Agriculture Canada, the Canadian Wheat Board, and the provincial governments, who gave us valuable ideas and suggestions. The following persons have made significant input into this statement: R. N. Brown, A. J. Macaulay, G. J. Mitchell, H. L. Sawatzky, W. D. Wishart, and F. C. Zwickel.

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Dynamics of Moose Populations near Rochester, Alberta, 1975–1978

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Mytton, William R., and Lloyd B. Keith. 1981. Dynamics of Moose populations near Rochester, Alberta, 1975–1978. Canadian Field-Naturalist 95(1): 39–49.

A Moose population was studied near Rochester, Alberta, from October 1975 to April 1978. Mean densities of Moose on 228 km² of nonagricultural land were 0.64/km² in winter 1975–1976. Fifty-nine Moose were radio-collared, and an additional 66 were color-collared. Sixty-one percent of the captured Moose (excluding calves) were yearlings and 2-yr-olds. The combined yearling-and-adult sex ratio averaged 25 bulls to 75 cows during winter 1975–1977. Radio-collared Moose exhibited both "migratory" and "nonmigratory" movement patterns. Distances between seasonal range centers of migratory individuals were significantly greater for bulls, i.e., 13 vs. 7 km. There appeared to be no difference between seasonal home range sizes of bulls and cows. Long-distance "dispersal" movements occurred among 1.5- to 2.5-yr-olds. Mean annual survival of radio-collared yearlings and adults was estimated at 0.84. Calf survival estimated from disappearance rates of calves of radio-collared cows, from demographic data, and from survival of radio-collared calves averaged 0.67 annually. Fecundity of migratory cows was probably higher than of nonmigratory ones. Calves averaged 39% of the winter population in six aerial surveys. Moose were located on aspen islands within muskegs during summer months and in open and treed muskeg during September–November. Movements to tall high-density upland aspen and conifer stands occurred in December and continued into March. During the last week of March and first week of April there was a marked shift into lowland areas. February and March were the only months when Moose were not located further from human disturbances than would be expected in a random distribution. The percentage of Moose having about one-third or more cleared land within a 1-km radius of their observed location increased from 17% in November to 48% in March.

Key Works: population dynamics, Moose, habitat, movements, radio-tracking, Alberta.

In October 1975, as part of the Alberta Oil Sands Environmental Research Program (AOSERP), we intensified our studies of Moose (*Alces alces*) near Rochester, Alberta. During the previous 10 winters we had routinely counted, classified (by sex and age), and plotted locations of Moose on 179 km² while conducting aerial surveys of Coyotes (*Canis latrans*) and White-tailed Deer (*Odocoileus virginianus*). These surveys indicated that the Moose population was increasing rapidly, and that both reproductive and recruitment rates were high (Rolley and Keith 1980).

Because the Moose population at Rochester was unhunted, essentially without predation, and on what appeared to be excellent range, it provided a fine opportunity to measure rates of increase and other demographic data under what were optimal conditions for Moose in northcentral Alberta. In other words, the Rochester population could be used as a base against which to compare the dynamics and growth potential of other regional populations. The Rochester population also offered opportunities to examine relationships between human disturbances and seasonal distribution and habitat usage by Moose.

The present paper is based on analysis of data obtained between October 1975 and April 1978. It is primarily concerned with population demography, movements, distribution, and habitat utilization as determined from radio-tracking.

Study Area

The 287-km² (112-mi²) Rochester Study Area was located 100 km north of Edmonton (Figure 1). About 21% was cleared for agriculture; 43% was upland forest dominated by Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*P. balsamifera*) with intermixed stands of Jack Pine (*Pinus banksiana*) and White Spruce (*Picea glauca*); 32% was bog containing scattered Tamarack (*Larix laricina*) and dense stands of Black Spruce (*Picea mariana*); and 3% consisted of ponds, lakes, and rivers. The western and southern sections of the study area bordered economically marginal farmland. Climate, soils, topography, and vegetation of the area have been summarized elsewhere (Weatherill and Keith 1969; Rusch et al. 1971; Keith and Windberg 1978).

There were three "survey" areas within the Rochester Study Area (Figure 1). The initial survey area of 179 km² (hereafter called the Helicopter Survey Area) was established in 1965 for monitoring Coyote and White-tailed Deer populations, but Moose were also counted each winter. The second area of 228 km² (the Moose Survey Area) was selected because Moose numbers appeared high there, and it was bounded by easily recognized road systems. The third area of 143 km² (the Intensive Survey Area) was mainly forested and had the highest Moose densities.

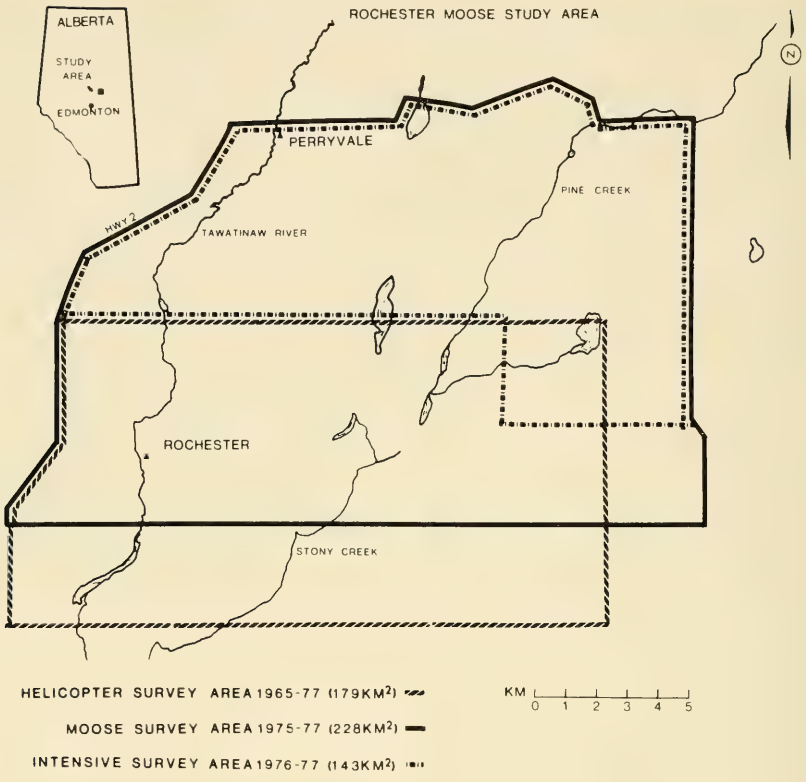

FIGURE 1. Location of Moose survey areas within the Rochester Study Area.

Methods and Materials

Capture, Marking, and Aging

During October 1975 – October 1977, 144 Moose were darted from Bell 206 and Hughes 500c helicopters, and immobilized with M99 (etorphine hydrochloride) or a mixture of fentanyl citrate, Rompun, and Wydase, as described by Haigh et al. (1977). Ninety-eight (39 bulls, 59 cows) Moose were captured during 29 October – 13 December 1975; 30 (15 bulls, 15 cows) during 22 October 1976 – 19 January 1977; and 16 (3 bulls, 13 cows) were recaptured during 17 October – 21 October 1977.

Fifty-nine of the above Moose were fitted with radio-collars; an additonal 66 were given color-coded collars (21 cm wide) for individual identification during aerial observations. All received numbered metal ear tags bearing our address.

An outside incisor was pulled on each animal (excluding calves) for age determination by tooth-cementum annuli (Sergeant and Pimlott 1959; Gasaway et al. 1978).

Relocations

Radio-collared Moose were relocated about every 10 d from a Cessna 185 equipped with two four-element yagi antennas connected to a switch box within the aircraft. We first determined approximate position by equalizing signal strength from each antenna, and then located the Moose either visually (79%) or by maximizing signal strength (21%). During summer 1976, locations were also obtained from the ground every 3 d by triangulating radio signals from an 18-m tower and two truck-mounted paired yagi antennas.

All locations were recorded on 1000-m-grid maps. Linear distances between successive locations were determined; home range size was estimated using Mohr's (1947) minimum-perimeter-polygon method.

Seasons were delineated from mean dates of arrival and departure of Moose on easily recognized seasonal ranges: winter (22 December to 2 April) and summer (12 May to 15 September).

During location flights we also recorded Moose

activity and number of associates, whether contact was visual, and habitat occupied when contacted. Our habitat descriptions utilized a forest classification system (Alberta Forest Service) that included species composition, density, and overstory height.

Population Surveys

We employed three types of aerial surveys to obtain demographic data on the Moose population: (1) east–west transects in a Cessna 185 at 0.8-km intervals, airspeed of 80–100 km/h, and altitude of 95–100 m agl (above ground level); (2) east–west transects in a Bell 206 helicopter at 0.4-km intervals, airspeed of 85 km/h, and of altitude 75 m agl; and (3) intensive random searching in a Bell 206 helicopter. Ratios of marked Moose observed on survey flights to total marked present were used in Peterson-index calculations to estimate numbers. Only radio-collared animals were considered as the marked cohort because we knew the number present on any given survey date.

Disturbance

An index to three human disturbance factors was obtained by measuring the nearest distance from each Moose observation to occupied dwellings, petroleum development, or graded roads. In addition, the extent of agricultural clearing tolerated by Moose was investigated by determining the amount of cleared land within 1 km of each Moose location. These observed values were then compared with theoretical distances to disturbance and percentage of clearing, as calculated from a random sample of 425 points on the 1000-m-grid map of the Rochester Study Area.

Results and Conclusions

Population Density

Rolley and Keith (1980) documented the growth of the Moose population on 179 km² at Rochester from 0.016/km² of nonagricultural land in winter 1965 to 0.75/km² by 1978.

We calculated a mean of 0.64 Moose/km² of nonagricultural land through four survey flights between 2 January and 20 February 1976 on the 228-km² Moose Survey Area (Table 1, Figure 1). This included the northern half of the 179-km² Helicopter Survey Area.

The only flights in winter 1976–1977 were on 11–12 December, and covered the 143-km² Intensive Survey Area (Figure 1). The observed marked-to-total ratio yielded an estimated density of 1.4 Moose/km² of nonagricultural land.

The above densities were three to five times higher than those 300 km north near Fort McMurray during 1976–1978 (Hauge and Keith 1981). This difference is likely related in part to the absence of large predators and legal hunting at Rochester. Densities similar to or higher than those at Rochester have been reported from Newfoundland (1.1–4.6/km², Bergerud and Manuel 1969), Minnesota (0.4–0.8/km², Peek et al. 1976), and Isle Royale (1.5–3.0/km², Peterson 1977).

Sex and Age Structure

Sex ratios of combined yearlings and adults were determined from six helicopter flights during December–February 1975–1976 and 1976–1977. The main criterion for sexing was presence or absence of a vulva patch (Mitchell 1970); antlers or antler scars were sometimes a convenient alternative method.

We observed a mean bull:cow ratio of 27:73 (n = 83) on surveys during December–February 1975–1976 (Table 2). The following winter a ratio of 23:79 (n = 117) was obtained. These ratios differed significantly from the 47:53 (n = 389) noted on darting flights during October–December 1975, and the 41:59 on relocation flights during July–November when 163

TABLE 1—Estimated numbers and density of Moose on the Rochester Study Area as determined from aerial surveys described in text

Area and winter	Date	Aircraft type	Total no. of Moose observed	Moose population estimate[a]	95% confidence limits	Moose per km² of nonagricultural land
Moose Survey	2 January	Fixed-wing	57	143	117–247	0.83(0.88)[b]
Area (228 km²)	19 January	Helicopter	64	93	54–188	0.54(0.85)
1975–1976	7 February	Fixed-wing	44	110	64–136	0.64(0.38)
	20 February	Helicopter	67	97	46–146	0.56(0.89)
Means			58	111		0.64(0.75)
Intensive Survey Area (143 km²) 1976–1977	11–12 December	Helicopter	119	135	75–218	(1.40)

[a] Peterson-index calculations: estimates based on ratio of radio-collared Moose seen to radio-collared Moose present.
[b] Densities in parentheses refer to 143 km² Intensive Survey Area (see Figure 1).

TABLE 2—Sex and age composition of the Moose population as determined from helicopter surveys at Rochester during winter (December–February)

Winter and survey date	Total no. of observations	Adult sex ratio bulls:cows (%)	% of population			
			Bulls	Cows	Calves	Unknown
1975–1976						
10 December	15	29:71	13	33	53	0
19 January	64	28:72	16	41	39	5
20 February	67	25:75	15	45	40	0
Total and weighted means	146	27:73	15	42	41	2
1976–1977						
11–12 December	119	27:73	18	49	34	0
16 December	33	15:85	9	52	39	0
1 February	33	17:83	9	45	45	0
Total and weighted means	185	23:77	15	49	37	0

incidental observations were made. This difference may indicate the following:

1) A differentially higher egress rate of bulls to adjacent game management units in late fall where they suffer increased mortality through hunting.
2) A differentially lower rate of ingress of bulls due to bull-only hunting in adjacent management units.
3) Sex-specific movement patterns which temporarily shift more bulls than cows off survey areas during winter.

The tendency for bulls to make longer seasonal movements than cows, as discussed later, tends to support (1) and (3) above. Further evidence of a higher egress rate among bulls were the reobservation rates of marked individuals as discussed by Rolley and Keith (1980). Yearling and adult bulls were reobserved significantly less often than other sex-and-age classes, with yearlings evidently disappearing at the highest rate.

In ungulate populations, tertiary sex ratios tend to favor females as a result of greater male mortality allegedly due to greater activity in general (including larger home-range size, and higher metabolic rates) and that associated with reproduction in particular (Flook 1970). Markgren (1971) reported that in Sweden, Moose embryos and calves were 55–58% males, whereas tertiary ratios usually favored females.

Bull:cow ratios in northeastern Alberta (26:74 in 1976, 33:67 in 1977) (Hauge and Keith 1981), where both hunting and Gray Wolf (*Canis lupus*) predation occur, were similar to those at Rochester (Table 2).

The sample of 64 Moose (excluding calves) that we darted and immobilized in October–December 1975 was composed of individuals taken as encountered, and should thus be representative of the population's age distribution. Thirty-three percent were yearlings, 28% were 2-yr-olds, and 39% were older animals. This distribution was not significantly different from the theoretical stable age distribution of 32:22:47 calculated from observed age-specific fecundity and survival rates (Rolley and Keith 1980).

Aggregations and Associations

Radio relocations enabled us to examine the seasonal aggregation of Moose and the attendant association of different sex and age-classes. We used Bergerud and Manuel's (1969) definition of an aggregation as any group of animals occurring within close proximity of one another.

Mean size of bull-dominated groups (more bulls in group than cows) varied from 1.0 (n = 65) in early August to 2.3 (n = 105) in November. During December–July, bulls were usually solitary. Largest bull-only aggregations occurred immediately after the rut (mid-October to late-November) when up to nine were seen together. There were no age-specific differences in size of bull-dominated groups, although it appeared that younger bulls (1.5–3.5 yr) remained with cows longer than did older bulls (August to January vs. September to November).

Cows with calves tended to be solitary throughout the year except for a brief period in September during the rut (Figure 2). At that time 57% of cows with calves associated with other adults or with yearlings; all of such associates were bulls. Similar groupings have been noted elsewhere (Geist 1963; Peek et al. 1974; Rounds 1978; Hauge and Keith 1981). Rounds (1978) found that during fall single cows associated with other adults up to 2 mo longer than did cows with calves. Our observations at Rochester suggest that an even longer period of association (August–December) is common (Figure 2).

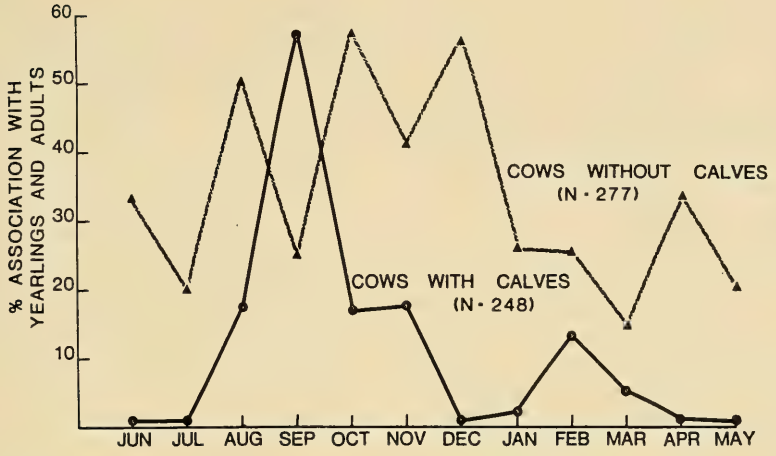

FIGURE 2. Percentage of radio-collared cow Moose, with and without calves, associated with other yearlings and adults at Rochester during October 1975 – April 1978.

Seasonal Movements and Home Ranges

We analyzed four types of Moose movements at Rochester: (1) short-term movements (3–14 d) between successive relocations; (2) seasonal "migrations" between lowlands to the east and uplands along the Tawatinaw River to the west; (3) seasonal shifts between lowlands and immediately adjacent uplands in the eastern portion of the study area; and (4) dispersal from the study area.

Movements between successive relocations of yearlings and adults were usually < 2 km, with 87% being < 5 km. Bulls made significantly more moves > 5 km than did cows. This was owing to the greater distances (means 13.4 vs. 4.9 km) between seasonal ranges (Table 3) and longer movements during the rut. Phillips et al. (1973) and Best et al. (1978) noted similar seasonal differences in length of daily or short-term movements.

As indicated in (2) and (3) above, our radio-collared Moose at Rochester exhibited two types of seasonal movements. The first involved five cows that made annual moves between their winter ranges along the Tawatinaw River uplands and summer ranges in the muskeg and lake region to the east. Three characteristics set this "migratory" cohort apart from the four "nonmigratory" cows that remained in the muskeg and lake region throughout the year: (1) individuals moving to the Tawatinaw River area were traditional in their use of wintering areas during successive winters, i.e., all were found on the same winter ranges during three successive years; (2) routes of travel between seasonal ranges were approximately the same each year; and (3) four of the five cows had no overlap between winter and summer ranges, and the other had only an 8% overlap (Figure 3). The four "nonmigratory" radio-collared cows had winter ranges and travel routes that differed each year, and a mean overlap between winter and summer ranges of 76%.

Three radio-collared adult (≥ 2.5 yr) bulls made seasonal movements similar to those of migratory cows. Two moved southwest to farmland areas, and one wintered along the Tawatinaw River about 5 km northwest of Perryvale (Figure 3). In each case, seasonal ranges were separated by at least 6 km, and two

TABLE 3—Mean distances in kilometres between the centers of summer and winter home ranges of radio-collared adult (≥ 2.5 yr) Moose at Rochester during 1976 and 1977

	Bulls		Migratory cows		Nonmigratory cows	
Year	No. of pairs of ranges	Mean distance (± SE)	No. of pairs of ranges	Mean distance (± SE)	No. of pairs of ranges	Mean distance (± SE)
1966	3	10.0 ± 2.5	5	6.6 ± 0.9	4	2.6 ± 0.5
1977	2	18.5 ± 6.7	5	7.0 ± 1.0	4	2.5 ± 0.4
Totals and weighted means	5	13.4 ± 3.6	10	6.8 ± 0.7	8	2.6 ± 0.3

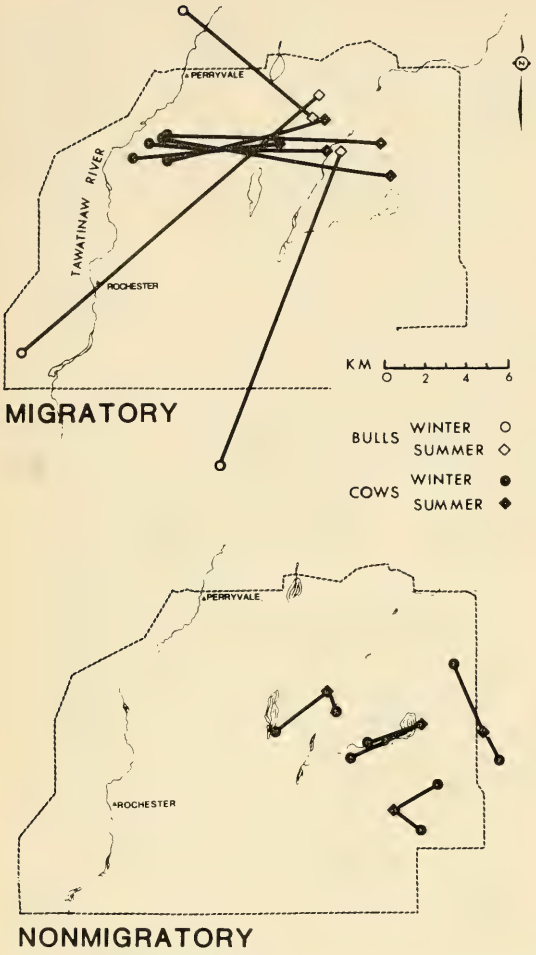

FIGURE 3. Movements between seasonal range centers for "migratory" and "nonmigratory" radio-collared adult (≥ 2.5 yr) Moose at Rochester during 1975–1977. Centers of ranges that were ≤ 0.5 km apart were combined as one point.

of the three winter ranges were situated off the study area.

Four calves (one male, three female), radio-collared concurrently with their mothers along the Tawatinaw River, returned there as yearlings in the following winter. These apparently learned movements were not exhibited by four other calves (three males, one female) that were permanently separated from their mothers during tagging operations on summer and fall ranges. The latter calves were nonmigratory, wintering on the summer ranges of their mothers. Two female calves separated after they had moved to the Tawatinaw River area returned there the following winter.

One radio-collared bull and three cows moved >50 km from the study area. All four were 1.5 or 2.5 yr old. Such dispersal occurred in late summer and early fall and was to the north and northwest. One additional bull, color-collared in 1975 as a yearling, moved 250 km west of Rochester during a 2-yr period.

In fall 1976, four yearlings (one bull, three cows) that as calves had migrated to the Tawatinaw River area with their mothers moved 10–50 km north and west of the study area. By late winter (mid-January to February), however, all four had returned to the areas on which they had previously wintered as calves. As 2-yr-olds in fall 1977, these same individuals moved directly to their previous winter ranges.

Mean dates of arrival on, and departure from, distinct seasonal ranges were used to delineate the following winter and summer periods:

1) Later winter to spring (22 December to 2 April): the period when Moose were on winter range.
2) Spring (3 April to 11 May): the period when Moose were between winter and summer ranges.
3) Summer (12 May to 15 September): the period when Moose were on summer range.
4) Fall and early winter (16 September to 21 December): the period of rut and movement between summer and winter ranges.

As Tester and Siniff (1973) pointed out in assessing the measurement of home range, size generally increases with the number of observations and/or the length of the observation period. At Rochester there was a direct relationship ($r^2 = 0.71$) between the number of Moose locations and the resulting estimate of home range size. We therefore compared seasonal ranges only where numbers of seasonal locations were similar. Chi-square tests indicated no statistically significant differences in home range size of bulls versus that of cows, but innate variability was high (1 km^2 to 54 km^2); nor was there a difference in size of seasonal ranges of yearlings and 2-yr-olds versus those of older individuals. Mean winter and summer home ranges of 15 km^2 and 16 km^2 at Rochester, based on 7–12 locations per animal (Table 4), were larger than those reported in other areas, from a similar number of locations (Houston 1968; Goddard 1970; Phillips et al. 1973), but were smaller than ranges determined by radio-tracking in northeastern Alberta (22–28 km^2 in winter and 37 km^2 in summer; Hauge and Keith 1981).

Survival Rates

Adult

Survival rates of radio-collared yearlings and adults were calculated using the method of Trent and Rongstad (1974). We used two approaches to calculation problems imposed by malfunctioning or lost collars: (1) only individuals whose fates were known to us were included in the first (maximum) estimate of sur-

TABLE 4—Mean home range size of radio-collared Moose during winter (December–March) and summer (May–15 September) on the Rochester Study Area as calculated from minimum perimeter polygons (Mohr 1947). Smallest and largest home range sizes shown in parentheses

	Winter		Summer	
No. of locations	Mean (km^2)	No. of Moose	Mean (km^2)	No. of Moose
3–6	3(1–18)[a]	21	4(1–16)	27
7–12	15(2–54)	45	16(1–34)[a]	16
13–19			25(11–39)	10
20–23			26(12–44)	9

[a]Home ranges were calculated for these two cells using randomly selected subsets from the 7 to 12 locations per Moose on winter ranges and the 13 to 23 locations on summer ranges.

vival; (2) the second (minimum) estimate assumed that all radio-collared individuals with whom we had lost contact died, even though radio malfunction was a possibility.

Four of the 32 yearlings and adults radio-collared on the Rochester Study Area were known to have died; one bull and one cow were legally shot in an adjacent game-management unit, one cow was poached, and another was struck by a truck. Four color-collared animals (three bulls, one cow) were poached on the east and northeast edge of the study area during September–November 1976 and 1977, and another was shot by a treaty Indian 250 km to the west in January 1978.

The annual survival rates of radio-collared yearlings and adults in 1976 and 1977 were 0.89 and 0.92 (assumption (1) above). Annual survival as calculated from assumption (2) was 0.76 and 0.79. The mean annual survival rate from these four different, but not independent, estimates was 0.84. This is probably our best estimate of survival; small sample sizes precluded any meaningful test for age- or sex-specific differences.

Calf

Information on calf survival was obtained from three sources; (1) 20 cows were radio-collared and the presence or absence of their calves noted at each relocation during mid-May to April; (2) winter calf:cow ratios, cow survival rates, population age structure, and age-specific fecundity rates were used to calculate May to January survival; (3) 27 calves were radio-collared during November–February and relocated thereafter.

Calves that disappeared from their mothers' sides during mid-May to 1 December were classified as mortalities because lone calves were not seen during fall and early winter relocation flights. On the other hand, disappearance of calves of radio-collared cows after 1 December could not be entirely equated with death: we know, for example, that 3 of 12 calves radio-collared during 24 November – 11 December had become separated from their cows by mid-January, but each survived the winter. Survival among 23 calves of radio-collared cows during the approximate 6.5-mo period from birth to 1 December was 0.73.

Mid-May to mid-January survival rate was estimated demographically from (a) the mean calf:cow ratio of 85:100 (n = 279) observed on six winter survey flights; (b) age-specific rates of fecundity of 0.57 and 1.67 calves for radio-collared yearling and adult cows; (c) a cow survival rate of 0.89 for 8 mo (from annual survival of 0.84 given earlier); and (d) a yearling:adult cow ratio of 33:77 (given earlier). The calculated calf survival rate was 0.58 over 8 mo (Table 5).

The foregoing estimates of calf survival are equivalent to 7-mo rates of 0.71 and 0.62, respectively. Their mean of 0.67 is probably our best estimate of survival

TABLE 5—Calculation of calf survival during mid-May to mid-January utilizing the mean calf:cow ratio in winter, age-specific fecundity, a yearling:adult cow ratio, and adult survival as given in text

Mean winter calf:cow ratio from six aerial surveys (mean, mid-January) × 85 calves:100 cows

Calculated calf:cow ratio at birth in mid-May:

3.33[a] (2-yr-olds) × 0.57 (calves:2-yr-old) = 0.19
0.67 (adults) × 1.67 (calves:adult) = 1.12
1.31 calves:cow

Estimated calf:cow ratio in mid-May = 131 calves:100 cows

Adult survival estimate from mid-May to mid-January = 0.89

Apparent calf survival rate to mid-January = 85:131 = 0.65

Calf survival to mid-January, corrected for cow survival = 0.65 × 0.89 = 0.58

[a]Proportion of 2-yr-olds in the May population.

during the first 7 mo of life. It is also likely a good estimate of total first-year survival, since all 15 calves radio-collared between 24 November and 5 February, and not permanently separated from cows during collaring, survived to April. In contrast, 4 of 12 calves that became permanently separated during radio-collaring died during February–April, thus supporting Markgren's (1964) suggestion of increased mortality among lone calves.

Calf Production

Calf:cow ratios and twinning rates among radio-collared adults (≥3.0 yr) were obtained within the first 10 d after birth in spring 1976. A calf:cow ratio of 167:100 (15:9) and a twinning rate of 88% (seven of eight) were observed at that time. By fall and early winter 1976 (September–December) the calf:cow ratio was down to 122:100 (11:9), and the apparent twinning rate was just 38% (three of eight).

In 1975 and 1977, calf:cow ratios during September–December were 175:100 (14:8) and 144:100 (13:9) and twinning rates were 75% (six of eight) and 44% (four of nine).

Seven yearling cows radio-collared between October 1975 and January 1977 as 2-yr-olds produced four calves: two single calves and one set of twins. This is a minimum estimate of yearling fecundity because dates of first visual observation after possible calving in mid-May were 20 May (2) and 9 July (2) for the four calfless cows and 25 November, 8 December, and 9 December for the three with calves.

The fecundity of cows that migrated to the Tawatinaw River area may well have been higher than those that did not migrate. Mean calf:cow ratios in spring were 200:100 (20:10) vs. 125:100 (5:4), respectively, and in fall 180:100 (27:15) vs. 100:100 (11:11); by fall apparent twinning rates were 80 and 9%, respectively.

Survey flights during winter 1975–1976 and 1976–1977 provided additional information on twinning rates and calf:cow ratios. Calves comprised 41% of the population during December–February 1975–1976 and 37% in 1976–1977 (Table 2). This was higher than elsewhere in Alberta: 22% in the Swan Hills (G. Lynch, Alberta Fish and Wildlife Division, unpublished data) and 20% near Fort McMurray (Hauge and Keith 1981). The greater percentage of calves at Rochester vs. Fort McMurray was also reflected in a markedly higher calf:cow ratio during December–February (85:100 vs. 51:100) and apparent twinning rate (39 vs. 12%).

Rolley and Keith's (1980) analysis of past survey data from Rochester showed consistently high reproductive rates over the period 1965–1977: winter calf:cow ratios and twinning rates were higher at Rochester than those observed *in utero* or immediately after birth in most other areas of North America.

Habitat Utilization

Availability of cover types was determined through a stratified random sampling of Alberta Forest Service cover maps (1:16 000) of the study area. Observed rates of cover usage were then compared to known availability.

Movements of radio-collared Moose within and between seasonal ranges were generally reflected by changes in habitat utilization. Both aspen-dominated uplands and muskeg-willow lowlands were used extensively during June–September (Table 6), with

TABLE 6—Percentage of use of different cover types as indicated by location of radio-collared Moose on the Rochester Study Area from October 1975 to April 1978[a]

Cover type	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Mean	Availability
Aspen	42	51	56	46	37	47	55	70	70	66	27	34	50	45
Aspen – Jack Pine	2	2			1	2	1	2	2	3		6	2	2
Aspen – White Spruce		1	1	3	1	3		1		1	1	4	2	5
Jack Pine			1		2	2		1	1	3	1		2	1
Jack Pine – Aspen						1			2				2	1
White Spruce	1	1			1			1	5	5	2		1	1
White Spruce – Aspen					1					6	1		3	2
Total upland usage	45	55	58	49	43	55	56	75	80	84	32	44	56	57
Aspen – Balck Spruce	1	1	1		1						1		1	1
Black Spruce	2	1	1	2	1					1	1		1	3
Muskeg – willow	52	44	40	49	56	46	43	26	20	15	66	55	43	34
Water														4
Total lowland usage	55	46	42	51	58	46	43	26	20	16	68	55	44	42
Total no. of observations	143	203	147	88	137	101	69	141	152	140	170	47	128	1649

[a]Field work suspended from 15 April to 1 July 1977.

bulls being located in lowlands significantly more often (47%) than cows (28%). Aspen areas used during the summer were usually islands and ridges of slightly higher relief scattered throughout the muskeg and lake region in the eastern portion of the study area.

During the rut (mid-September to mid-October) both sexes used adjacent open muskegs more frequently. From mid-October through November, post-rut aggregations of bulls were commonly in muskegs (54% of locations), whereas cows utilized aspen islands (80% of locations). As bull aggregations gradually disintegrated, lowland use decreased to less than 30% by mid-December.

Use of tall high-density aspen stands increased from December into March (Table 6); such cover was frequented more by bulls (67%) than by cows (56%) during February–March. Utilization of uplands peaked in March when over 84% of the radio-collared Moose were relocated there. Rolley and Keith's (1980) 1965-1979 surveys during December–March suggested the same overwinter changes in habitat use. Our comparison of usage and availability indices suggested that Moose actively selected these high-density aspen stands (Table 6).

A striking shift into open lowlands occurred during the last week of March and first week of April. The increased frequency of locations in lowlands (from 6 to 54%) during this 2-wk period coincided with the loss of snow (reduced to trace amounts by 25 March in 1976 and 7 April in 1977). The 68% utilization of lowland sites during the last week of April was greater than at any other time of year. Berg and Phillips (1974) and Hauge and Keith (1981) found a similar situation in Minnesota and northeastern Alberta where movements to low open willow (*Salix* spp) habitats occurred in early to mid-April. A synopsis of the above-described seasonal differences in habitat use by Moose is given in Table 7.

Moose Distribution in Relation to Human Disturbance

The distribution of radio-collared Moose in relation to human disturbance factors varied seasonally (Figure 4). Movements from summer to winter ranges brought Moose into closer proximity with sources of disturbance, as most uplands on the Rochester Study Area were utilized for roads, buildings, and farmland.

Early to late winter movements into remnant densely forested uplands shifted both migratory and nonmigratory Moose toward the farmland border, with mean distances to disturbance decreasing from 1.1 km in November to 0.6 km in March (Figure 4).

February and March were the only months when Moose were not located significantly farther from disturbance than would be expected on a purely random distribution basis. As distance to disturbance decreased through winter, the amount of cleared land within 1 km of each Moose observation increased. Seventeen percent of Moose relocations in November, and 48% in March, were in areas having greater than one-third cleared land (Figure 4). But average utilization of cleared land was, during all months of the year, less than would be expected if distribution had been random. Rolley and Keith (1980) reported similar trends in distance to human disturbance in their analysis of November–March surveys conducted at Rochester during 1965–1979.

There was great variation in the amount of clearing that Moose tolerated. A 4.5-yr-old radio-collared

TABLE 7—Synopsis of seasonal distribution of Moose at Rochester in relation to major habitat characteristics. Data from locations of both radio-collared and unmarked individuals

Season	Total no. of observations	% of Moose in specified habitat	Habitat characteristics			
			Topography	Vegetation	Overstory density[a]	Overstory height (m)
Summer (12 May – 15 September)	475	69	Uplands	Deciduous	Medium to high	> 9
Fall (16 September – 21 December)	361	63	Uplands and open lowlands	Deciduous islands in muskeg	Low	< 9
Winter (22 December – 2 April)	433	82	Uplands	Deciduous–conifer	Medium to high	> 9
Spring (3 April – 11 May)	290	53	Lowlands	Muskeg willow	Low	< 9

[a]Forest density rating used by Alberta Forest Service.

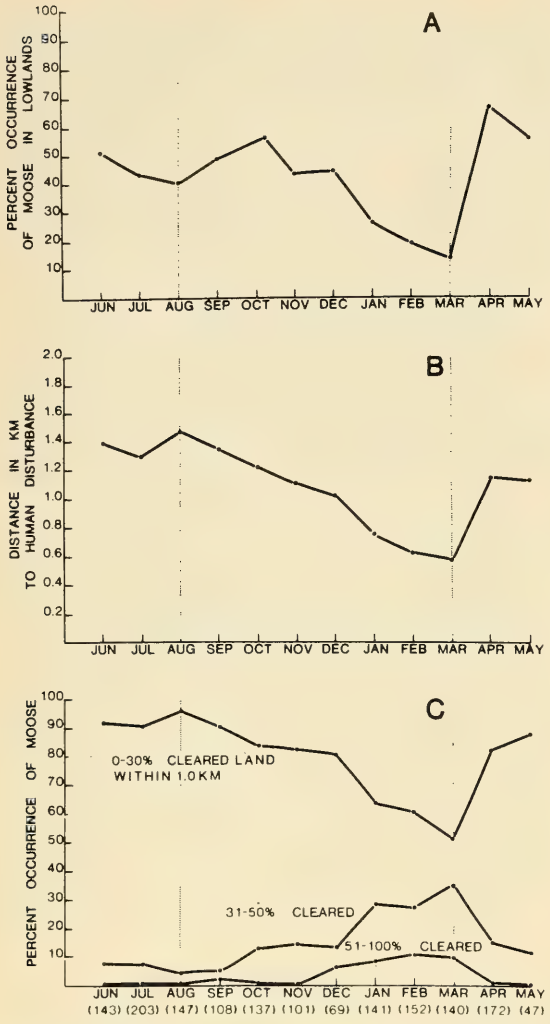
A
PERCENT OCCURRENCE OF MOOSE IN LOWLANDS
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
B
DISTANCE IN KM TO HUMAN DISTURBANCE
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
C
PERCENT OCCURRENCE OF MOOSE
0-30% CLEARED LAND WITHIN 1.0 KM
31-50% CLEARED
51-100% CLEARED
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
(143) (203) (147) (108) (137) (101) (69) (141) (152) (140) (172) (47)

FIGURE 4. Monthly distribution of radio-collared Moose in relation to indices to human disturbances: (A) utilization of lowland areas; (B) distance to roads, buildings, and petroleum development; (C) changes in percentage of cleared land found within 1 km of each Moose observation at Rochester during October 1975 – April 1978. Number of monthly observations shown in parentheses.

bull, for example, was relocated for 3.5 mo during all three winters (1975–1978) in areas of between 75 and 95% cleared land, while other individuals rarely ventured into areas of more than 25% clearing. Such inherent variability prevented generalizations about tolerance of Moose to human disturbance. It seemed, however, that most animals did not tolerate areas of >30% cleared land for extended periods.

During spring, movements away from disturbance occurred when snow depths decreased to trace amounts (25 March — 7 April). These movements took Moose from the aspen uplands to the more isolated muskegs and other lowlands (Table 7) where they calved. The mean distance to disturbance increased through spring and summer (1.2 km in April, 1.5 km in August), then decreased in mid-September with the onset of the rut.

Acknowledgments

We are grateful to R. Frokjer, F. Gingerich, J. Jorgenson, and P. Mytton for field and office assistance; to J. Cary for computer and statistical advice; and to T. Fuller, T. Hauge, R. Rolley, and the fixed-wing and helicopter pilots without whose help this project would not have been possible. We also thank J. Kemp, G. Lynch, D. Neave, K. Thirwell, R. Weatherill, and many other members of the Alberta Department of Recreation, Parks and Wildlife (Fish and Wildlife Division) for logistical support. This project was funded by the Alberta Oil Sands Environmental Research Program and Fish and Wildlife Division.

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Received 24 September 1979
Accepted 23 May 1980

Régime alimentaire des Orignaux du sud-ouest Québécois pour les Mois d'Avril à Octobre

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Crête, Michel et Peter A. Jordan. 1981. Régime alimentaire des Orignaux du sud-ouest québécois pour les mois d'avril à octobre. Canadian Field-Naturalist 95(1): 50–56.

On a analysé le contenu de 64 rumens d'Orignaux (*Alces alces*) récoltés entre 1977 et 1979 dans la réserve de La Vérendrye, Québec. La période considérée a été divisée en quatre: printemps, début de l'été, fin de l'été et automne. Les ramilles dominaient le régime alimentaire des Orignaux au printemps jusque vers le 15 mai et les feuilles le reste du temps; à l'automne, les ramilles dominaient à nouveau dans les rumens vers la mi-octobre. Le Sapin Baumier (*Abies balsamea*), l'If du Canada (*Taxus canadensis*) et l'Erable à Epis (*Acer spicatum*) représentaient les espèces les plus communes dans les rumens au printemps; durant tout l'été, l'Erable à Epis prédominait dans la nourriture des Orignaux alors qu'il cédait sa place aux cerisiers (*Prunus* spp.) à l'automne. Les petits nés au printemps pouvaient posséder une nourriture de même nature que celle des adultes dès la fin de juin. Une proportion importante des femelles a semblé ne pas s'alimenter pendant la période du rut en 1978. On a conclu que l'Erable à Epis constitue la base du régime alimentaire annuel des Orignaux dans une bonne partie du Québec.

Mots clés: Orignal, Québec, érable, régime alimentaire, *Alces*.

Crête, Michel et Peter A. Jordan. 1981. Régime alimentaire des Orignaux du sud-ouest québécois pour les mois d'avril à octobre. Canadian Field-Naturalist 95(1): 50–56.

The study was based on the analysis of 64 samples of Moose (*Alces alces*) rumen content collected in La Vérendrye Reserve, Quebec, between 1977 and 1979. The interval between April and October was divided into four periods: spring, beginning of the summer, end of the summer, and fall. Twigs dominated rumen contents in spring until approximately 15 May and leaves thereafter; in fall, twigs dominated again by mid-October. Balsam Fir (*Abies balsamea*), Ground Hemlock (*Taxus canadensis*), and Mountain Maple (*Acer spicatum*) composed the bulk of the browse in spring; Mountain Maple dominated Moose diet in summer and was replaced by cherry (*Prunus* spp.) in autumn. Calves could have a diet similar to that of adults starting at the end of June. Many females seemed to stop feeding during the rut in fall of 1978. Mountain Maple appears to represent the yearlong basis of Moose nutrition in many areas of Quebec.

Key Words: Moose, Quebec, maple, food habits, *Alces*.

Le bilan énergétique des cervidés d'Amérique du Nord fait voir un cycle annuel qui se caractérise par un gain de poids en été et une perte en hiver (Franzmann et al. 1978; Moen 1978). La fin du printemps et l'été constituent par conséquent une période importante puisque les animaux refont leurs réserves. La qualité et l'abondance de la nourriture alors disponible prennent encore plus d'importance pour les femelles qui doivent aussi affronter les exigences de la fin de la gestation et de la lactation (Gasaway et Coady 1974; Verme 1977; Bahnak et al. 1979). Enfin, le régime alimentaire précédant la période de reproduction influence l'âge à la puberté des femelles (Abler 1974) et leur taux d'ovulation (Verme 1969).

Dans le cadre d'une étude sur la dynamique des populations d'Orignaux (*Alces alces*) du sud-ouest du Québec (Crête et al. 1981), il fallait donc considérer la qualité et la quantité de nourriture disponible en été. Mais premièrement, fallait-il connaître le régime alimentaire de cette espèce animale. Le but de cet article est de décrire les habitudes alimentaires estivales de l'Orignal dans la région d'étude; aucune étude n'a encore touché ce sujet en profondeur dans l'est du Canada. L'analyse du contenu de rumens d'Orignaux s'avérait une technique appropriée pour atteindre cet objectif.

Région d'étude

La moitié sud de la réserve de La Vérendrye, sise à environ 300 km au nord-ouest de Montréal, constituait la région d'étude. Cette réserve est traversée par une route asphaltée importante qui relie le nord-ouest du Québec aux régions plus au sud. On y compte environ 60 accidents routiers impliquant des Ori-

gnaux et des véhicules automobiles par été. De plus, on y tient une chasse contrôlée de l'Orignal au cours de laquelle 150–200 bêtes sont abattues annuellement (Bouchard et Moisan 1974). Les échantillons analysés provinrent de ces deux sources.

La réserve de La Vérendrye possède un relief ondulé (altitude: 300-500 m), typique du Plateau Laurentien. Des sols podzoliques s'y sont développés à partir d'une assise rocheuse surtout granitique (Service de Gestion de l'Environnement, 1977. Documentaire sur le bassin de la rivière des Outaouais. Pêche et Environnement Canada). Les précipitations annuelles atteignent en moyenne l'équivalent de 900 mm de pluie, dont près de 30% tombe sous forme de neige (Ferland et Gagnon 1967). En moyenne, le débourrement des bourgeons a lieu vers le 15 mai alors que la défoliation débute vers le 15 septembre (Villeneuve 1969).

Des forêts mélangées contenant des feuillus tolérant l'ombre (surtout le Bouleau Jaune, *Betula alleghaniensis* et l'Erable à Sucre, *Acer saccharum*) occupent souvent la partie supérieure des collines; le bas des versants et les terrains plats sont surtout couverts de forêts mélangées contenant des feuillus intolérants (principalement le Bouleau à Papier, *Betula papyrifera* et le Peuplier Faux-Tremble, *Populus tremuloides*). Les feux de forêts qui étaient historiquement plus fréquents dans la deuxième catégorie de peuplements expliquent en grande partie la distribution des deux communautés végétales dominantes (Crête 1977). Les conifères les plus importants, le Sapin Baumier (*Abies balsamea*) et l'Epinette Blanche (*Picea glauca*) ont été affectés par la Tordeuse du Bourgeon de l'Epinette (*Choristoneura fumiferana*) de façon parfois très sévère. L'Erable à Epis (*Acer spicatum*) constitue l'arbuste le plus abondant (Crête 1977) et le plus important pour l'Orignal en hiver (Joyal 1976).

Méthode

Un échantillon d'environ 1 L du contenu des rumens d'Orignaux était prélevé dans les 8 h suivant la mort de l'animal; il était ensuite conservé dans une solution de formol 10%. Une des deux premières incisives I_1 était aussi arrachée et conservée dans une solution de formol 3%.

Au laboratoire, chaque échantillon de contenu de rumen était séparé en trois, selon la taille des fragments, à l'aide de tamis munis de mailles de 6.3–4.0 et 1.7 mm (Bergerud et Russel 1964; McCaffery et al. 1974; Skinner et Telfer 1974). L'eau servait à entraîner les particules d'un tamis à l'autre; les fragments qui n'étaient pas retenus par les mailles les plus fines n'étaient pas considérés. Lorsque l'échantillon était dominé par des fragments de plantes non ligneux (le cas le plus fréquent), on retirait d'abord, par espèce, les ramilles des trois tamis. On déterminait ensuite l'importance relative des fragments non ligneux des deux premiers tamis par échantillonnage; on étendait une partie du contenu d'un tamis dans un bac peu profond où l'on répartissait systématiquement 100 points-échantillon à l'aide d'aiguilles à pointe fine (Chamrad et Box 1964). A chaque visée, on tentait d'identifier à l'espèce le fragment cible. Comme l'identification des fragments non ligneux était pratiquement impossible pour le tamis aux mailles de 1.7 mm, on devait assumer que sa composition végétale était similaire à celle des deux premiers tamis. On séchait enfin les ramilles et le contenu des trois tamis à une température de 70°C pendant 72 h et l'on pesait. Lorsque l'échantillon était dominé par des ramilles, il était très laborieux de séparer les ramilles et les particules non ligneuses du troisième tamis; aussi la séparation n'était faite que pour un sous-échantillon et l'on extrapolait à tout le tamis. De plus, lorsque les ramilles dominaient, il était souvent plus rapide de séparer par espèce les fragments non ligneux des deux premiers tamis que de procéder par échantillonnage.

L'identification des fragments de plante n'était pas facile; pour s'aider, le technicien examinait d'abord les feuilles et/ou ramilles encore entières dans l'échantillon, consultait une collection de plantes séchées et demandait l'avis de personnes plus familières que lui avec la végétation de la région d'étude. De plus, ce technicien avait développé une série de critères d'identification pour plusieurs espèces communes.

L'âge des Orignaux a été déterminé par le décompte des annuli de cément entourant la racine de la première incisive I_1 (Sergeant et Pimlott 1959); le plan de coupe était transversal. Cette technique n'était pas nécessaire pour les petits de l'année que l'on reconnaît à leur taille.

Enfin, l'équipe affectée à l'étude de la dynamique des populations d'Orignaux de la région d'étude notait, par espèce, la présence de feuilles d'arbres et d'arbustes broutées par les Orignaux lors de ses déplacements en pleine forêt. Les observateurs notaient simplement la présence d'espèces broutées sans évaluation quantitative et deux observations devaient être distantes d'au moins 50 m.

Compte tenu des stades de développement de la végétation et du nombre d'échantillons disponibles, la période de temps couverte a été divisée en quatre: printemps (avant le 15 mai), début de l'été (15 mai au 14 juillet), fin de l'été (15 juillet au 14 septembre) et automne (après le 15 septembre). L'analyse statistique s'est limitée à la comparaison de distributions de fréquence par le test du chi-carré; les moyennes présentées sont suivies de l'erreur standard de la moyenne ($s_{\bar{x}}$).

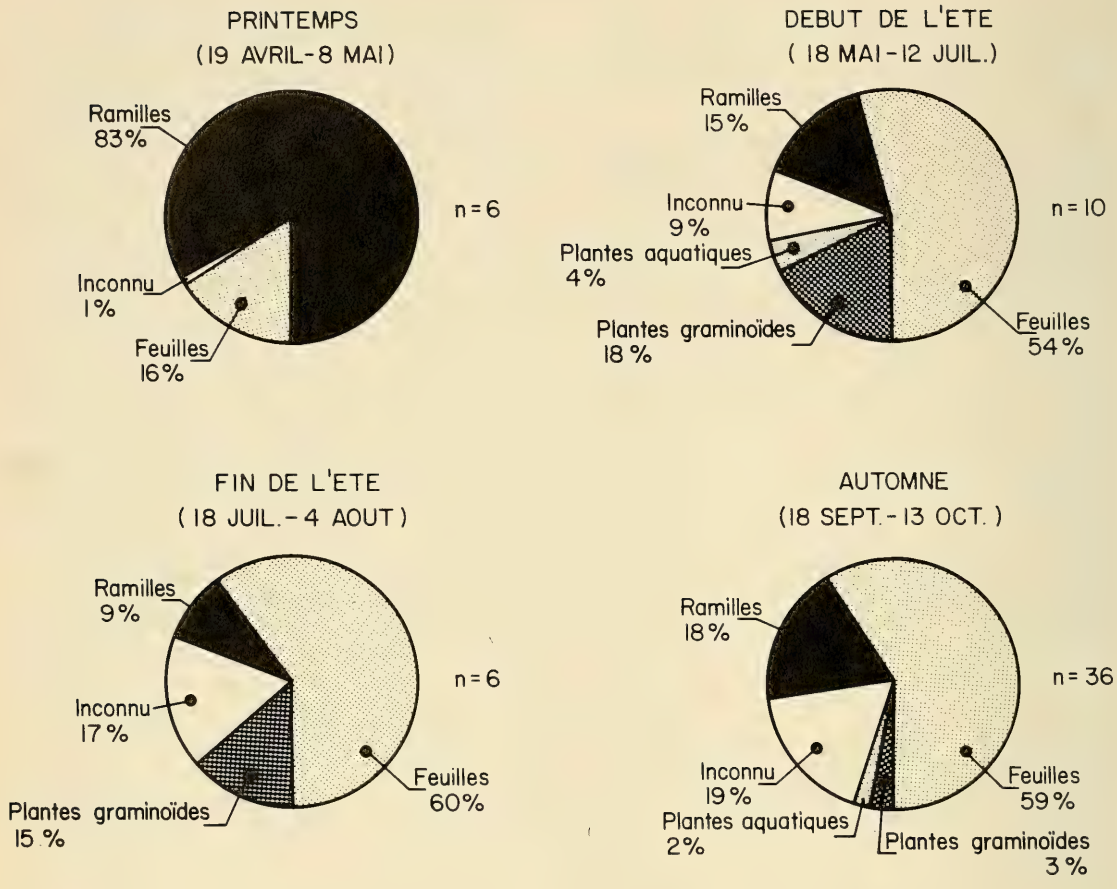

FIGURE 1. Composition en poids sec du contenu des rumens d'Orignaux selon des groupes de plantes pour quatre périodes de l'année. Les dates entre parenthèses indiquent le jour de la première et de la dernière collection. Les inconnus n'incluent que des fragments non ligneux.

Résultats

Soixante-quatre échantillons de contenu de rumen ont été récoltés entre avril 1977 et août 1979; le tiers des prélèvements provint d'Orignaux tués sur la route, le reste d'Orignaux récoltés à la chasse. Les jeunes de l'année représentaient 8% de ces individus alors que l'on comptait 42% de mâles parmi les adultes. L'âge moyen des adultes était de 4.2 ans ± 0.5 (n = 44). Ces statistiques suggèrent que l'échantillonnage était représentatif de la population sur pied (Bouchard et Moisan 1974; Crête et al. 1981).

Même si l'identification des fragments végétaux des rumens est difficile, seulement 22% ± 2.5 (n = 50) et 27% ± 2.7 des parties de végétaux ne purent être identifiées dans le premier et le second tamis respectivement. En excluant les fragments non identifiés, le test du chi-carré a révélé une composition végétale identique des deux premiers tamis pour 64% des 50 échantillons contenant plus d'une espèce végétale (ou groupe d'espèces).

Evolution du régime alimentaire au cours de la saison

La figure 1 fait voir la nature du régime alimentaire des Orignaux pour les quatre périodes. Les végétaux rencontrés dans les rumens d'Orignaux ont été regroupés selon qu'ils étaient des parties d'arbres ou d'arbustes (feuilles ou ramilles), des plantes graminoïdes ou des plantes aquatiques. Cette division permet entre autres d'identifier le type d'habitat fréquenté par les Orignaux puisque les arbres et arbustes croissent en milieu terrestre alors que les plantes aquatiques se retrouvent naturellement dans les plans d'eau; sans en avoir l'assurance formelle, on croit que les plantes graminoïes (cypéracées, gram-

inées, joncacées) rencontrées dans les rumens croissaient aussi dans ou près des plans d'eau.

Au printemps, ce sont les ramilles qui dominent largement le régime alimentaire des Orignaux de la région d'étude; les aiguilles de conifères constituent la majorité des feuilles consommées durant cette saison. Au début de l'été, on note un changement radical alors que les feuilles deviennent dominantes dans les rumens; on note aussi que c'est le moment où les plantes aquatiques et les plantes graminoïdes abondent le plus. Joyal et Scherrer (1978) ont d'ailleurs montré que la fréquentation des plans d'eau par l'Orignal était la plus grande au début de l'été dans le sud-ouest du Québec. La nature du régime alimentaire ne change pas tellement à la fin de l'été: tout au plus, les feuilles prennent-elles un peu plus d'importance. A l'automne, les feuilles demeurent encore la composante principale de la nourriture de l'Orignal. Les plantes graminoïdes deviennent passablement moins fréquentes alors que l'inverse s'observe pour les ramilles. Dans ce dernier cas, il est bon de noter qu'avant le 10 octobre, les ramilles ne représentent que 12% du contenu des rumens alors qu'entre le 10 et le 13 octobre (dernier jour de la chasse dans la Réserve), elles comptent pour 32% du poids des échantillons. C'est donc vers la mi-octobre que les ramilles redeviennent majoritaires dans le régime alimentaire des Orignaux; à ce moment, la défoliation est généralement très avancée (Villeneuve 1969).

La plupart des études touchant le régime alimentaire des Orignaux au cours de la période sans neige se sont limitées à comparer l'importance relative des feuilles d'arbres et d'arbustes. Toutefois, Belovski et al. (1973) ont estimé à environ 13% la proportion, en poids sec, des plantes aquatiques dans la nourriture estivale des Orignaux de l'Isle Royale, le reste étant constitué de feuilles; cette estimation est du même ordre de grandeur que nos résultats si l'on suppose que la majorité des plantes graminoïdes rencontrées dans les rumens croissaient en milieu aquatique. En Alaska, l'observation, au cours des mois de juillet et d'août, de trois Orignaux apprivoisés a permis d'estimer que les feuilles représentaient environ 65% de la nourriture de ces animaux, et que, comparativement à l'étude présente, les plantes aquatiques et graminoïdes perdaient de l'importance au profit des plantes annuelles à feuilles larges (LeResche et Davis 1973). Dans le même état, Cushwa et Coady (1976) ont observé pour leur part que les ramilles dominaient les contenus de rumen au printemps, que les feuilles étaient plus importantes en été et que les Orignaux broutaient occasionnellement des plantes herbacées au printemps et en été.

Le tableau 1 permet d'identifier les espèces végétales qui sont les plus importantes pour l'Orignal pendant la période considérée. Ainsi, au printemps, le Sapin Baumier, l'If du Canada (*Taxus canadensis*) et l'Erable à Epis comptent pour plus du trois quarts des

TABLEAU 1—Importance relative (%) des végétaux retrouvés dans les rumens d'Orignaux selon la saison, 1977–1979, réserve de La Vérendrye, Québec. Les espèces représentant moins de 0.5% des fréquences d'observation ont été omises

	Printemps[a] (n = 6)	Début de l'été[b] (n = 10)	Fin de l'été[b] (n = 5)	Automne[b] (n = 36)
Abies balsamea	29	10	—	1
Taxus canadensis	24	T[c]	T	T
Acer spicatum	24	68	68	21
Thuja occidentalis	2	—	—	—
Prunus spp.	1	4	12	52
Salix spp.	13	3	14	6
Populus tremuloides	1	2	6	3
Typha spp.	—	6	—	2
Dryopteris spp.	1	—	—	5
Diervilla lonicera	—	—	—	4
Corylus cornuta	3	—	—	T
Acer saccharum	—	—	—	2
Eriocaulon septangulare	—	2	—	T
Betula spp.[d]	1	—	—	1
Myrica gale	—	1	—	T
Viburnum alnifolium	1	—	—	—
V. cassinoides	1	—	—	—
Mousses	1	2	—	T

[a]D'après le poids sec des ramilles.
[b]D'après le contenu des tamis à maille de 6.4 et 4.0 mm.
[c]Trace (< 0.5%).
[d]Surtout *Betula papyrifera*.

ramilles identifiées dans les rumens. La consommation en grande quantité de sapin et spécialement d'if est particulière à cette saison car, en hiver, ces deux espèces sont beaucoup moins utilisées dans la région d'étude (Joyal 1976; Crête données non publiées); d'ailleurs, l'if est peu disponible en hiver à cause de sa petite taille. Au début de l'été, l'Erable à Epis devient l'espèce dominante dans le régime alimentaire des Orignaux, représentant près de 70% des fragments non ligneux identifiés. Par ailleurs, la présence d'aiguilles de sapin et d'if dans les rumens après le 15 mai s'explique en grande partie par leur long temps de digestion (Bergerud et Russel 1964). Parmi les plantes aquatiques identifiées, les typhas (*Typha* spp.) sont les plus fréquemment rencontrées. A la fin de l'été, l'Erable à Epis compose encore la majeure partie de la nourriture des Orignaux. Le Peuplier Faux-Tremble et les cerisiers (*Prunus* spp.) possèdent quand même une importance appréciable. A l'automne, l'Erable à Epis cède le premier rang aux cerisiers (surtout *P. pensylvanica*). De plus, des espèces tels le Dièreville Chèvrefeuille (*Diervilla lonicera*) et les dryoptérides (*Dryopteris* spp.), qui sont rarement broutées en d'autres temps, font leur apparition dans la nourriture des Orignaux. Ces changements de préférence sont probablement attribuables au fait que les Orignaux recherchent les espèces qui conservent leurs feuilles vertes le plus longtemps à l'automne. D'avril à octobre, les saules (*Salix* spp.) occupent toujours une fraction importante du régime alimentaire des Orignaux; si leur importance est moindre au Québec qu'au Minnesota (Peek et al. 1976) ou qu'en Alaska (Cushwa et Coady 1976), c'est probablement pour la simple raison qu'ils sont moins abondants dans la région d'étude.

Les observations d'arbres et d'arbustes broutés par les Orignaux (tableau 2) confirment la grande importance que revêt l'Erable à Epis pour ces cervidés dans le sud-ouest du Québec en été. Si l'importance relative de l'Erable à Epis est moindre d'après les observations visuelles que d'après les contenus stomacaux, c'est surtout que la première estimation ne représente qu'une fréquence d'occurence. De plus, il est fréquent que ces deux méthodes conduisent à des estimations différentes, l'observation visuelle étant moins complète (Smith et Shandruk 1979). L'importance de l'Erable à Epis s'étend probablement à tout le sud du Québec car cette espèce est souvent abondante dans les aires d'hivernage d'Orignaux des autres régions de la province (Brassard et al. 1974). Ces résultats vont toutefois à l'encontre des observations de Joyal et Scherrer (1978) qui, pour la période estivale dans un secteur situé à environ 100 km à l'est de la région d'étude, calculèrent que le Cerisier de Pennsylvanie dominait la nourriture des Orignaux. Cette contradiction apparente semble attribuable à la faible superficie de leur aire à l'étude, où d'ailleurs, l'Erable à Epis était rare (environ 10 km²: R. Joyal, Université du Québec à Montréal, communication personnelle). Par ailleurs, l'Erable à Epis semble jouer un rôle de moins en moins important pour l'Orignal au fur et à mesure que l'on s'éloigne vers l'ouest, comme le suggèrent les résultats de l'Isle Royale (Belovski et al. 1973; Miquelle et Jordan 1979) et du Minnesota (Peek et al. 1976).

TABLEAU 2—Fréquence d'occurrence (%) d'arbres et d'arbustes broutés par l'Orignal entre juin et août dans le sud-ouest du Québec, établie à partir d'observations faites lors de déplacements en pleine forêt, en 1978 et 1979

Espèce	Fréquence d'occurrence (n = 118)
Acer spicatum	40
Viburnum cassinoides	9
Prunus pensylvanica	8
Betula papyrifera	8
Corylus cornuta	7
Viburnum alnifolium	7
Acer saccharum	5
Autres[a]	16

[a]Comprend par ordre d'importance: *Populus tremuloides, Betula alleghaniensis, Sorbus americana, Salix* spp., *Acer rubrum, Diervilla lonicera, Cornus stolonifera, Lonicera canadensis, Cornus alternifolia, Nenopanthus mucronatus.*

Variation du régime alimentaire en fonction de l'âge et du sexe

Les trois échantillons provenant de petits de l'année qui furent récoltés au courant de l'été montraient une composition semblable à celle des adultes. Les spécimens du 30 juin et du 30 juillet faisaient voir une nette dominance de l'Erable à Epis alors que l'échantillon du 12 juillet était dominé par les plantes graminoïdes. Dans ce dernier cas, la mère du petit avait été tuée lors du même accident; la comparaison statistique du contenu des rumens de la mère et du petit (fragments non ligneux des deux premiers tamis) a révélé une différence très nette ($P < 0.005$), l'Erable à Epis dominant le contenu du rumen de la mère. Ainsi les jeunes Orignaux peuvent commencer à brouter une nourriture semblable à celle des adultes avant l'âge d'un mois, mais ils ne semblent pas nécessairement imiter en tout point les habitudes alimentaires de leur mère.

Durant l'automne 1978, six échantillons parmi les 14 prélevés sur des femelles étaient complètement liquides, ne permettant l'identification d'aucun fragment. Par contre, pour la même saison, aucun échantillon provenant de 16 mâles ne possédait cette caractéristique, ni ceux récoltés à l'automne 1977 (8 femelles, 4 mâles). Cette observation permet

d'avancer l'hypothèse que certaines femelles cessent de s'alimenter pendant le rut: le fait qu'aucun corps jaune d'ovulation n'ait été observé dans sept ovaires provenant de ces six femelles, toutes aptes à la reproduction, suggère qu'elles étaient sur le point d'ovuler, ce qui donne plus de vraisemblance à l'hypothèse avancée. Par contre, en 1977, on comptait cinq corps jaunes et un follicule primaire fraîchement rupturé dans 10 ovaires disponibles provenant des huit femelles. Le phénomène de jeûne observé en 1978 s'étendit du 21 septembre au 8 octobre.

Discussion

L'analyse du contenu des rumens d'Orignaux s'avère particulièrement laborieuse. Puglisi et al. (1978), confrontés à ce problème, ont proposé des moyens de rendre la technique plus efficace en rapport avec le Cerf de Virginie. Dans le même but, pour l'Orignal, nous recommandons de n'utiliser qu'un seul tamis muni de mailles d'environ 6 mm; il faut, en effet, considérer que dans 64% des cas, les deux premiers tamis possédaient une composition semblable et que de toute manière, cette technique est plus descriptive que quantitative pour trois raisons: (1) certains végétaux ou parties de végétaux sont plus facilement identifiables que d'autres; (2) après la première identification d'une espèce ou groupe végétal, on anticipe à nouveau sa présence dans l'échantillon; (3) la vitesse de digestion des végétaux n'est pas uniforme (Bergerud et Russel 1964).

Miquelle et Jordan (1979) spéculant sur le rôle de la diversité dans le régime alimentaire de l'Orignal, ont émis l'hypothèse que ce cervidé choisissait comme nourriture de base en été l'espèce végétale comestible la plus abondante d'une région donnée; d'après leurs résultats, ils avancèrent que cette espèce devrait représenter 60–70% de la prise alimentaire quotidienne. Nos résultats supportent assez bien cette hypothèse puisque l'Erable à Epis constitue de fait l'espèce comestible la plus disponible dans la région d'étude (Crête et Jordan, données non publiées).

Les faiblesses de la technique employée n'empêchent pas de conclure que l'Erable à Epis constitute la base du régime alimentaire de l'Original du sud du Québec. Des travaux antérieurs (Brassard et al. 1974; Joyal 1976; Bédard et al. 1978) avaient montré l'importance de cette espèce végétale pour les Orignaux en hiver; les résultats présentés ici montrent qu'en fait, l'Erable à Epis est probablement encore plus important en été.

Remerciements

Je veux d'abord remercier le personnel de la réserve de La Vérendrye, les guides, les chasseurs et quelques consoeurs et confrères de travail pour avoir recueilli les échantillons. Je veux d'autre part souligner le travail méticuleux de K. Levine qui a fait l'analyse des contenus de rumen en laboratoire. Je veux aussi exprimer ma reconnaissance à R. Ouellet qui a estimé l'âge des bêtes. Merci enfin à J.-R. Moreau pour la figure et à J. Huot et R. Joyal pour leur commentaire du texte original.

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Received 2 May 1980
Accepted 11 August 1980

Caribou (*Rangifer tarandus*) Encounters with Pipelines in Northern Alaska

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Hanson, W. C. 1981. Caribou (*Rangifer tarandus*) encounters with pipelines in northern Alaska. Canadian Field-Naturalist 95(1): 57–62.

Behavior of Caribou (*Rangifer tarandus*) upon encountering an experimental gas pipeline berm in northern Alaska suggested that a visual barrier effect greater than 1.2 m above ground level had a pronounced effect of deflecting the movements of Caribou. Animals readily traversed lower berms but avoided high berms and thermokarst areas.

Key Words: Caribou, northern Alaska, pipeline, visual barrier, behavior.

Development of the oil fields on the North Slope of Alaska has created one of the most serious confrontations of industrial and conservation interests of our time. The principal center of controversy has been the Trans-Alaska pipeline, the 1288-km conduit of 1.2-m-diameter steel pipe that moves the oil from Prudhoe Bay to Valdez. The environmental implications of such an installation are considerable in view of the severe local damage to northern Alaska from past exploration and initial development activities (Brooks et al. 1971; Klein 1970; Laycock 1970; Weeden and Klein 1971). Experiments by Child (1974) with Caribou encountering pipeline simulations at Prudhoe Bay and the observations by Cameron et al. (1979) and Roby (1978) of Caribou behavior along the Trans-Alaska pipeline and haul road have verified that Caribou are sensitive to these human activities and installations associated with oil development. Several of these reports have emphasized the lack of direct experience upon which to predict or mitigate Caribou reactions to pipelines and other installations in northern tundra environments. I herein report observations of northern Alaska Caribou encountering a raised berm resulting from pipeline burial similar to the general type of construction expected to be undertaken to transport natural gas from the Prudhoe Bay area southward, pending the approval of various government agencies and the surmounting of several engineering and economic problems.

Study Area and Methods

The study area was a natural gas pipeline installation and operation of the Gas Arctic Systems Study Group research facility at Prudhoe Bay, Alaska (Figure 1). This installation consisted of a 610-m (2000-ft) rectangular loop of standard "Alyeska pipe" (1.2-m diameter) through which refrigerated air (the test gas) was circulated during the 1971–1973 study period. A static pipeline test area and a road construction simulation test area were included in the study. The pipeline loop was so constructed that the east 243-m (800-ft) side was half buried in the substrate and covered with a 0.8-m (2.5-ft) berm and fill of residual material and gravel, resulting in a raised barrier of 1.0–1.7 m above the tundra. The west 243-m side was fully buried in the tundra under a berm ranging in height from nearly level with the surrounding terrain to about 0.8 m above ground level (agl). This pipeline was constructed during April–May 1971 in the continuous permafrost with high ice content which is typical of much of the North Slope landscape. Most of the berms were finished with a 3:1 slope. In the middle of the 61-m south side of the loop, the pipeline rose and passed through a refrigeration, heating, and power control center. The pipeline substrate was implanted with thermocouples, strain gauges, heat flux transducers, conductivity probes, soil moisture and soil density instruments to study permafrost regression, thermal patterns of the berm and fill materials, and other geological phenomena. The northeast corner of the pipeline passed through a 400-m^2 thaw pond in which temperature and water chemistry were studied. Eleven 3-m-tall cross-shaped metal deflection poles (Figure 2) were vertically mounted on the east and west legs of the pipeline at 15.2-m intervals to provide means of measuring pipeline movement optically. Two 36.5-m sections of nonoperating instrumented pipeline, one section half buried and the other fully buried, were located about 75 m east of the pipeline loop to study static pipeline effects. These sections were within an 8.1-ha (1 ha = 10 000 m^2) ice road construction simulation test area for studying winter tundra preparation for equipment traffic expected during pipeline construction.

The location of the Prudhoe Bay Test Site within the oil field area was fortuitously isolated from other

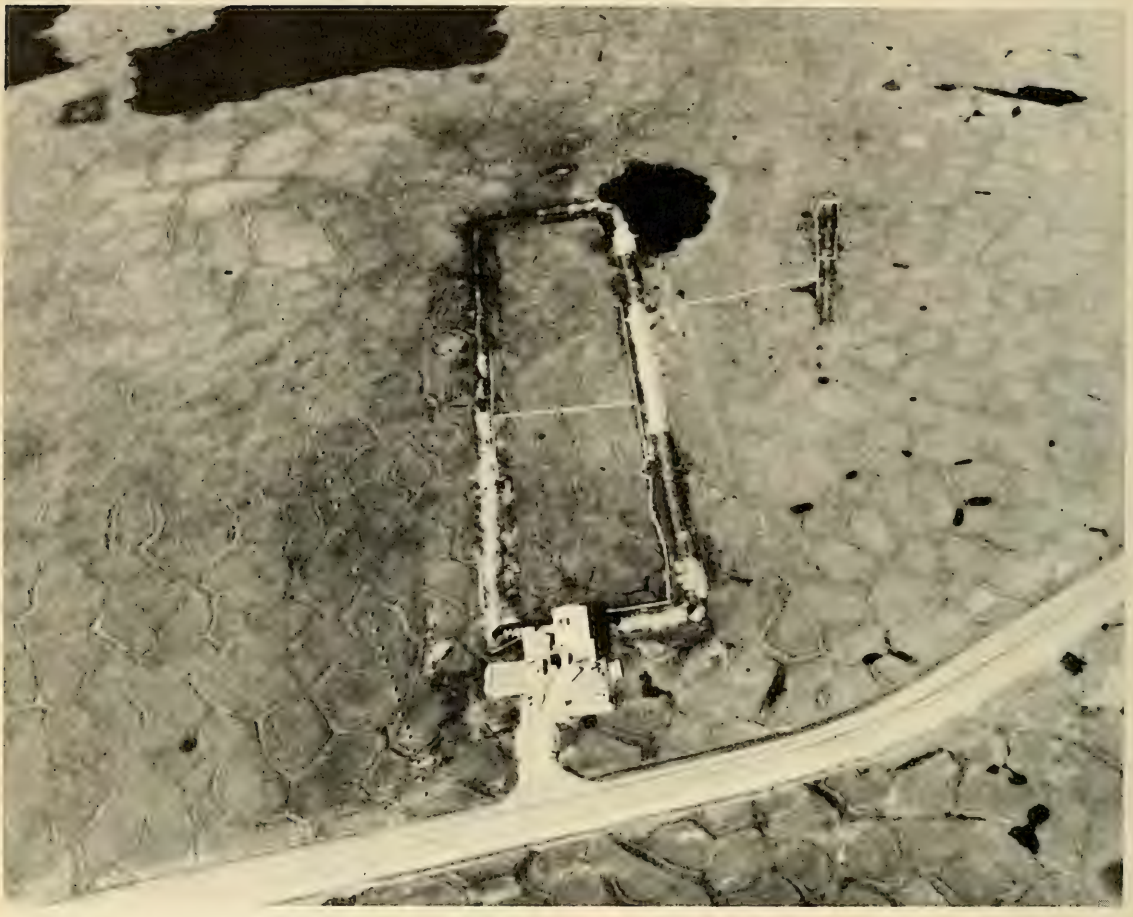

FIGURE 1. Aerial photo of the Prudhoe Bay Test Site during August 1971. The installation consists of a 610-m rectangular loop of 1.2-m-diameter pipe, of which the western side (left) was fully buried and the eastern side was half buried. Control center is in lower left, static test and road construction simulation test areas are located at right. The Prudhoe Bay spine road crosses lower part of photo. Light-colored barrels outlining the Gas Arctic Systems Study Group leased property were removed to facilitate Caribou encounters with the pipeline berms. Reticulated ground pattern results from buried ice wedges forming polygons characteristic of many arctic coastal plain areas of high ice content permafrost.

industrial installations and oriented in such a manner that Caribou moving between the Sagavanirktok River mouth and western portions of their summer range encountered the pipeline berms. These encounters were documented by visual observations made from an elevated platform constructed adjacent to the control center and downwind of the pipeline loop and from animal tracks in the substrates. Berms were inspected twice daily and raked free of tracks after photographic documentation of each encounter. Ten encounters occurred in 1971 and 24 episodes of Caribou–pipeline interactions during 1972 were combined into 21 separate encounters.

Results and Discussion

The 1971 encounters began a few days after bands of 36, 51, and 60 Caribou were observed 3 km north of the facility. The animals initially kept their distance from the test facility probably because the nearby spine road carried appreciable vehicular traffic. Six encounters were visually documented and the other four occurred while I was absent from the facility (usually late evening until early the following morning). Seven encounters were by single animals and three were by two animals each, reflecting the general dispersal of Caribou on their summer range (Hemming 1971), especially in the Prudhoe Bay area.

FIGURE 2. Photograph of Caribou in 1971 coursing east berm at point where it is 1.1 m high. Animal at this point carried its head with eye level ca.0.5 m above grade. Cross-shaped metal deflection poles were 3.05 m tall with 1.0-m crossarms.

The 1972 interactions involved a broader spectrum of animal groups than the 1971 data and ranged from single animals interacting with the pipeline berms on a single occasion to a band of five bulls that interacted on 18 occasions, either singly, in combinations, or as a group.

Most of the encounters during both seasons occurred at the north and west sides of the loop, where berm heights were lower and there was less noise from the facility diesel power generators and vehicular traffic, although the latter impacts did not appear to affect the Caribou greatly. Other field experiments with sound simulators operated in northeastern Alaska during Caribou migration periods (McCourt et al. 1974) suggest that the vehicular traffic was probably more important than the generator noise in deterring the Caribou. The animals readily crossed the berms of both residual material and gravel, especially where berm height was <1.2 m. Encounters at berm heights >1.2 m were characterized by animals (1) approaching obliquely, pausing at the top of the berm, and then descending in the direction from which they had approached (Figure 3); (2) first crossing lower berms on their way to revegetation plantings on the higher berms and usually retracing their paths to leave the study area over lower berms, as in the southwest corner of the pipeline loop (Figure 4); (3) interacting as a group, usually under the leadership of a large bull; or (4) under severe insect harassment from nostril flies (*Cephenemyia trompe*), warble flies (*Oedemagena tarandi*), and mosquitoes (*Aedes* spp.). Caribou often laid or stood on the gravel berms to seek relief from insect harassment (Figure 5).

The animals avoided the northwest sector of the pipeline loop in 1971 (Figure 3) where several pools of water were formed by melting snow and general subsidence related to melting ice wedges fractured by the pipeline construction. This behavior was similar to

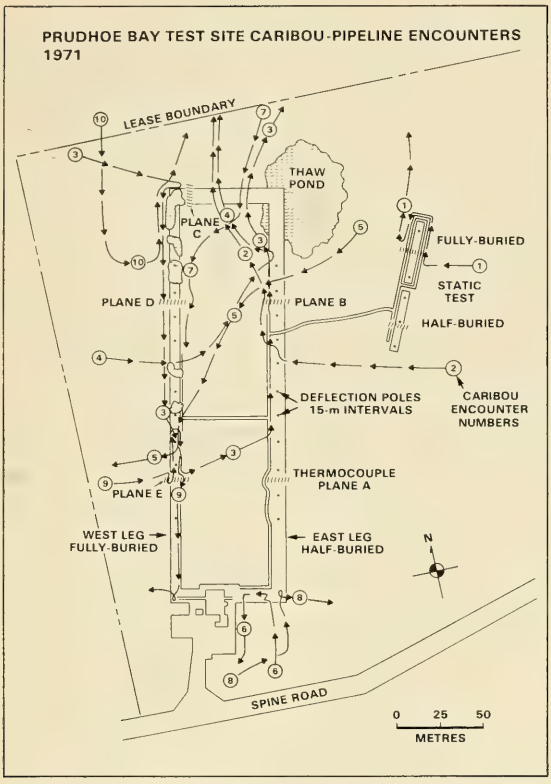

FIGURE 3. Schematic diagram illustrating routes of Caribou involved in 10 pipeline encounter episodes from 23 July to 2 August 1971. Detailed routes are shown to illustrate avoidance of higher (1.7 m) berms in southeast sector and pools of water in subsidence craters in northwest sector.

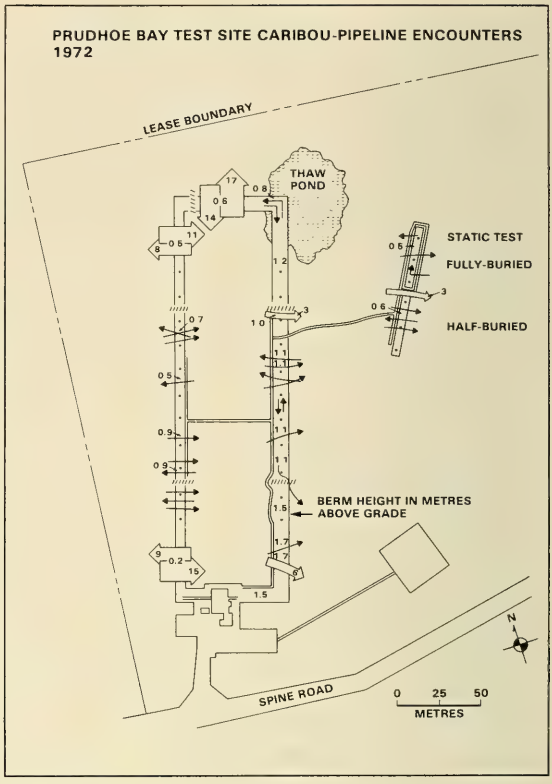

FIGURE 4. Schematic diagram illustrating routes used by Caribou in the 21 encounters from 15 July to 4 August 1972. Large open arrows indicate number of Caribou and direction of crossing berms, small dark arrows represent individual animal paths. Numbers in center of pipeline berms indicate maximum height (m) above grade. Note increased use of northwest sector following reclamation of subsidence craters, apparent selection of north and west berm sectors for entry, and east berm for exit.

that of Caribou encountering "topographic confinement" at a nearby study area (Child 1974). These areas were reclaimed by adding topsoil during April 1972, so that the Caribou then used the areas regularly (Figure 4).

Most Caribou appeared wary of deflection poles, thermocouple planes, and boardwalks and usually avoided them. However, during 1972 a large-antlered bull walked atop the east berm for a distance of 130 m, tilting his antlers to avoid the crossarms of eight deflection poles in his path. Clearance under the crossarms ranged from 0.9 to 1.4 m. He then continued a course toward an elevated (1.0–1.5 m) effluent line, which he coursed for 56 m before lightly touching his antlers to the wooden housing 2–3 times at a point where clearance was 1.1 m. He then continued to a point where clearance increased to 1.5 m and passed under the line. The animal was under moderate to severe insect harassment during the episode.

Two bull Caribou in 1971 (Figure 3) obviously avoided the combination of thermocouple housing and boardwalk in the static test area. They reacted by adopting the alarm stance, urinated, alertly watched the installation, and then bolted and trotted in a tight circle. Such behavior was earlier described by Pruitt (1960). This reaction was similar to that noted several times during summer when Caribou encountered roadways that they could not see over. In such cases, they often appeared uneasy and laid down for some time; others would intermittently graze while watching the road and vehicles, crossing warily when lulls in traffic permitted. As such behavior resulted in successful crossings, it was misinterpreted by some persons as unqualified acceptance by Caribou of man's activities and installations. Roads, airstrips, and

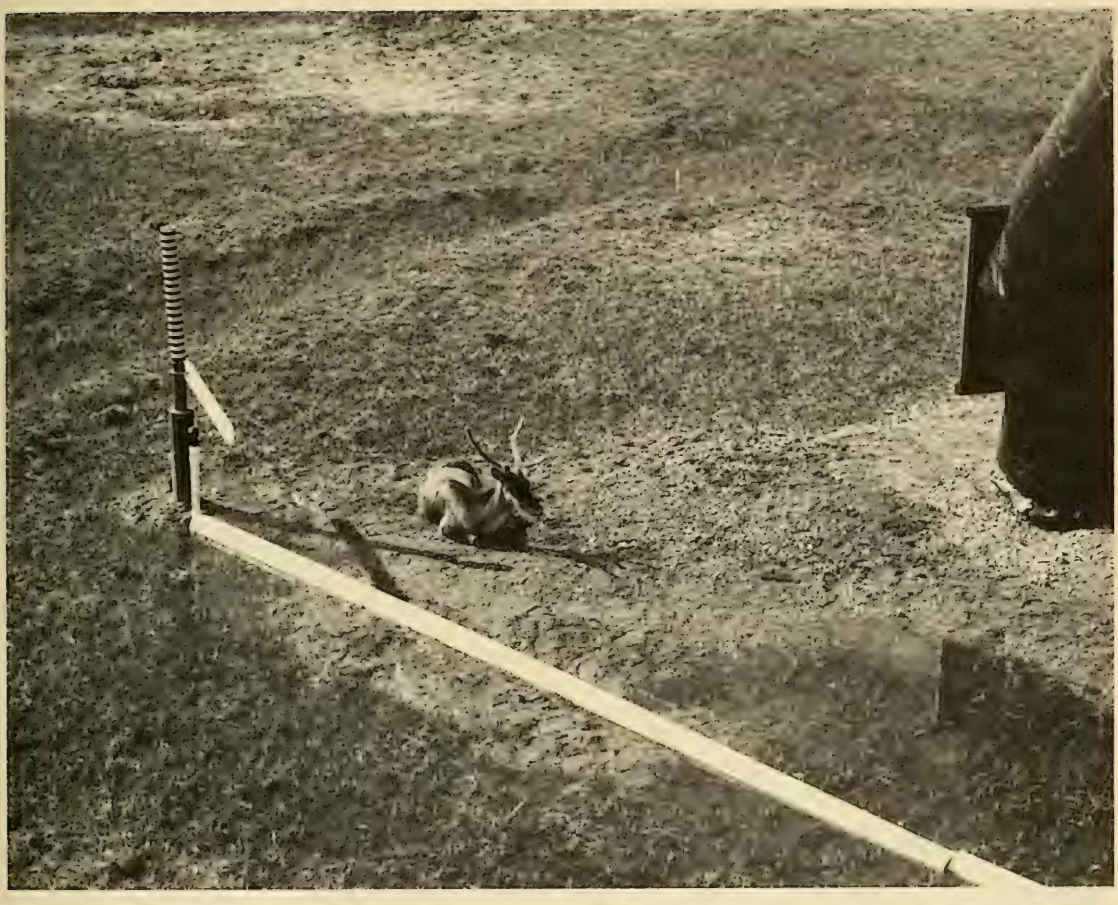

FIGURE 5. Caribou resting on gravel berm to obtain relief from insect harrassment. Animals appeared undisturbed by steady noise from diesel generator exhaust located about 60 m away and on opposite side of control center.

equipment pads on the North Slope are usually constructed of 1.5–2 m of gravel to insulate the permafrost and to allow winds to sweep them clear of snow during the winter. This height also makes them attractive to Caribou harassed by insects in summer, and once on the elevated structures the Caribou appeared reluctant to leave them. I watched a cow and her calf repeatedly trot back and forth over a 1-km interconnecting gravel road to avoid vehicle traffic rather than leave the breeze-swept elevated roadway during the peak of the mosquito season.

Further evidence of an important "visual barrier" effect operative in Caribou behavior toward the berms was supplied during a 1971 encounter. A cow, accompanied by her calf, climbed the gravel berm and paused at a point that provided a view of the lake in her path, and then left the study area over a lower berm. Why the lake should deter her is a matter of conjecture; the proximity of an alternative and easier route over lower berms with minimal visual obstruction that had been previously used by the animals in an earlier encounter perhaps provided the stimulus for her decision.

Caribou were attracted to fertilized revegetation plantings of Arctared Fescue (*Festuca rubra*), Nugget Bluegrass (*Poa pratensis*), and several other exotic grasses at several locations on the experimental pipeline berms during the 1972 season. The attractiveness of these plantings was probably a factor in the acceptance of the relatively high berms in the southeast corner of the loop by a five-bull band that contributed most of the encounters during 1972.

These observations are by no means indicative of the entire spectrum of Caribou behavior upon encountering pipeline berms. Herd behavior is different from that of individuals or small bands (Child

1974), and extrapolations from one to the other are tenuous. Seasonal differences in behavior may also be a consideration because of weather conditions, physiological variables, and social organization of Caribou herds. However, it was apparent that Caribou discriminated in their acceptance of certain of the pipeline berms studied and a number of encounters were recorded. The greater acceptance of the pipeline berms by bulls in 1972 compared to the behavior of cows and calves during both seasons and the decreased sensitivity to the installation with increased experience is consistent with observations of Caribou behavior along the oil pipeline and haul road (Roby 1978). However, insect harassment was concluded to be the greatest inducement for Caribou on their summer range to accept crossing facilities of the oil pipeline simulation (Child 1974).

These observations suggest that suitable gas pipeline crossings for Caribou might be attainable if they are knowledgeably located (LeResche and Linderman 1975; McCourt et al. 1974) and properly constructed. From experience in Scandinavia, Klein (1971) stressed the importance of utilizing traditional crossings, and in this report I have suggested that the visual barrier implications may be moderated by constructing pipeline berms of <1.2 m, or otherwise engineering them so that visual accommodation can be made by Caribou (Banfield 1974).

Acknowledgments

Amos Mathews, former Executive Vice-President of Alaskan Arctic Gas, gave approval to use the data reported herein. K. N. Child, L. E. Eberhardt, J. E. Hemming, and D. R. Klein made many helpful comments on the manuscript. This report was prepared under United States Department of Energy Contract No. DE-AC06-76RLO 1830.

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Received 20 May 1980
Accepted 12 August 1980

Analysis of Weight Lost by Eggs of Eleven Species of Birds during Incubation

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Manning, T. H. 1981. Analyses of weight lost by eggs of eleven species of birds during incubation. Canadian Field-Naturalist 95(1): 63–68.

From 4 to 323 eggs of 11 species of birds were weighed at least twice during incubation to determine daily weight loss. Pipped eggs were excluded. There was an unexplained difference between years in the daily weight loss of two species, the Red-winged Blackbird, *Agelaius phoeniceus*, and the Barn Swallow, *Hirundo rustica*. For six species the variance of daily weight loss was partitioned into egg and clutch components. Their means were 62.6% for eggs and 37.4% for clutches. The mean coefficient of variation for nine species, based on total variance (eggs and clutches), was 28.7. The reduced major axis equation for the daily weight loss (L) on fresh egg weight (W), using data for 56 species from this and other studies was $L = 0.143 W^{0.747 \pm 0.0255}$ ($r = 0.968$). The total weight lost during incubation as a percentage of fresh egg weight averaged 14.1 ± 0.64 for 11 species. The reduced major axis equation for daily weight loss multiplied by length of incubation period (I) on fresh egg weight was $L \cdot I = 0.153 W^{0.95 \pm 0.052}$ ($r = 0.987$) or on natural scale $L \cdot I = -0.116 + 0.152 \pm 0.0073 W$ ($r = 0.990$). These equations indicate an average weight loss of 15% of fresh egg weight during incubation.

Key Words: bird, egg, clutch, weight loss, incubation, partition of variance, coefficient of variation.

Weight loss by eggs during incubation is caused almost exclusively by diffusion of water vapor through the shell pores (Kendeigh 1940; Rahn and Ar 1974). The weight loss therefore varies with the porosity, or its equivalent (Ar et al. 1974); water vapor conductance of the shell; as well as with humidity, temperature, and barometric pressure (Ar et al. 1974). Data on weight loss during incubation has been recorded fairly frequently and Drent (1970) collected from the literature records of 46 species, including one, the Sora, *Porzana carolina*, also used in this study. Most of the records used by Drent are casual observations made in connection with other studies, and none that I have been able to check give standard errors or related statistics. The purpose of the present paper is to record the fresh egg weights and daily weight losses during natural incubation of eggs of 11 common birds, to examine the variability of the losses, to partition the variance into egg and clutch components, and to examine the relationship between the fresh weight of eggs and both the daily weight loss and the total weight lost during incubation.

Materials and Methods

In 1975, I weighed and measured eggs at North Point, Ontario, near the south end of James Bay and in 1976, 1978, and 1979 near Merrickville, about 50 km S of Ottawa, Ontario (see Table 1 for data base and scientific and common names of the birds). The 50-g Pesola balance used at North Point read to 0.5 g and could be estimated to 0.1 g, but was not sufficiently accurate to measure weight loss of the smaller eggs individually. Small eggs were therefore weighed as whole clutches or in the case of the Sora as partial clutches (lots). The two to five eggs that made up a lot were randomly taken from within a single clutch, so that there was no lot variance component, apart from that attributable to eggs, and the lot variance therefore provides an unbiased estimate of the egg variance. At Merrickville I used 10-g and 5-g Pesola balances. These read to 0.2 and 0.1 g. respectively, and could be estimated to 0.02 g with reasonable consistency. All eggs were therefore weighed individually. At North Point eggs were usually weighed at 2-d intervals, and in some cases every day; at Merrickville they were either weighed twice, usually at 6- to 10-d intervals, or three times, usually at 4-d intervals. Times were recorded to the nearest hour at both places. At North Point I marked the eggs with numbers in India ink, at Merrickville with small dots of red nail polish, a more efficient method. Wind was often a problem in the open marshes; to counter this at North Point, I suspended the scale in a large tin can, and at Merrickville in a transparent acrylic cylinder.

Except for the two Eastern Phoebe clutches, which were laid in the same nest and almost certainly by the same female, I avoided late clutches, and I think that all or almost all eggs measured in any one year were laid by different females. Also the American Robin eggs used in 1978 were in nests at least 1 km distant from the two nests used in 1976, and therefore were probably laid by different females. The 1978 Barn Swallow eggs were, however, from the same barn as those used in 1976. Similarly, the 1976, 1978, and 1979 Red-winged Blackbird eggs were from small marshes within the same area of about 2 km radius.

As the rate of weight loss increases rapidly after an

egg is pipped (Barth 1952; Rahn et al. 1976), eggs with a visible pipping fracture were excluded from the study. At Merrickville the first day of incubation was also excluded and usually balanced by the exclusion of 1 or 2 d at the end of the incubation. The periods covered by the weight loss measurements were, therefore, near the central part of the incubation period (Table 1) and should give a good estimate of the average daily weight loss for the whole period prior to pipping, even if, as has been found in some species (Kendeigh 1940; Fisher 1969; Sotherland et al. 1980), the rate of weight loss increases during incubation. As the Sora begins incubation early in the laying period, and up to 18 eggs were found in a single nest, some nests contained eggs that were just starting to be incubated as well as eggs nearing full term. The average period of weight-loss measurements was, however, probably not far from the middle of the incubation period. I had no means of knowing when a Sora had started incubation, but as only one clutch (five eggs) had less than seven eggs when first weighed and as only two more eggs were added to that clutch, it is reasonable to suppose that all the Sora eggs weighed were being incubated.

As some nests were not found before the start of incubation, and some eggs, that had been weighed when fresh, were later destroyed by predators, the mean fresh egg weight for most species was estimated from the reduced major axes (RMA) for fresh egg weight on volume index (length $\times$ breadth^2) of those eggs that were weighed on the day they were laid (Table 1), and the volume index of all eggs used for weight-loss determination. Exceptions were (1) American Bittern, for which the ratio rather than the RMA was used; (2) Wilson's Phalarope, the eggs of which lay flat in water, and were therefore thought to have been incubated from 0 to 2 d (Hays and Le Croy 1971) and their weight adjusted for 1 d of incubation; (3) Common Grackle, all eggs of which were weighed on the day laid; (4) Savannah Sparrow, for which the RMA was calculated from eggs weighed in clutches on the day the clutch was completed.

Weight losses used for calculating the means and variances were weighted by the length of the period covered by the observations. Fresh egg weights were similarly weighted. The 95% confidence intervals for egg variances are the least unbiased intervals; those for clutches were calculated by Scheffé's method (Sokal and Rohlf 1969) and are not exact, owing to unequal numbers of eggs in the clutches. The standard errors of the percentages of the clutch components, calculated according to Formula 4 of Swiger et al. (1964) for the variance of interclass correlation, are approximate for the same reason. The significance of differences between both means and regression coefficients were tested by t, differences between variances by F. The incubation periods are the periods between the laying of the last egg and the hatching of that egg. They were derived from various sources including this study, but for most species precise data were lacking.

TABLE 1—Number of eggs (clutches in parentheses) used for weight-loss estimation, number weighed when fresh, and difference in days between midpoint of time over which weight loss was measured (MWL) and midpoint of incubation (MI)

Species and years	No. eggs (weight loss)		No. eggs (fresh)		MWL-MI
	North Pt.	Merrickville	North Pt.	Merrickville	
American Bittern, *Botaurus lentiginosus* (1975)	8 (2)	— (—)	— (—)	1 (1)	+7
Sora, *Porzana carolina* (1975)	71 (18)	— (—)	24 (8)	— (—)	0?
Killdeer, *Charadrius vociferus* (1975)	15 (4)	4 (1)	3 (2)	4 (1)	-4
Common Snipe, *Capella gallinago* (1975, 1976)	11 (3)	4 (1)	12 (3)	— (—)	-4
Wilson's Phalarope, *Steganopus tricolor* (1975)	4 (1)	— (—)	— (—)	— (—)	-3
Eastern Phoebe, *Sayornis phoebe* (1978)	— (—)	9 (2)	— (—)	5 (1)	-1
Barn Swallow, *Hirundo rustica* (1975)	19 (3)	— (—)	— (—)	— (—)	-2.5
(1976)	— (—)	44 (10)	— (—)	44 (10)	-1.3
(1978)	— (—)	31 (7)	— (—)	24 (5)	-0.5
American Robin, *Turdus migratorius* (1976, 1978)	— (—)	26 (8)	— (—)	36 (13)	-1.5
Red-winged Blackbird, *Agelaius phoeniceus*					
(1975)	119 (29)	— (—)	— (—)	— (—)	+0.4
(1976)	— (—)	59 (17)	— (—)	69 (19)	-1.3
(1978)	— (—)	67 (19)	— (—)	67 (21)	-0.8
(1979)	— (—)	78 (22)	— (—)	11 (3)	-1.9
Common Grackle, *Quiscalus quiscula* (1976)	— (—)	10 (2)	— (—)	10 (2)	0.0
Savannah Sparrow, *Passerculus sandwichensis*					
(1975)	19 (4)	— (—)	14 (3)[a]	— (—)	-0.4

[a]See Materials and Methods.

Results and Discussion

Differences between Years

The weight-loss measurements of the Red-winged Blackbird eggs at Merrickville covered three seasons and those of the Barn Swallow two seasons (Table 1). Differences (11.4 $mg \cdot egg^{-1} \cdot d^{-1}$ for the Red-winged Blackbird and 6.0 $mg \cdot egg^{-1} \cdot d^{-1}$ for the Barn Swallow) between 1976 and 1978 weight-loss means (Table 2) are highly significant ($P < 0.01$). This was particularly surprising as all eggs laid in any one year were believed to have been laid by different females, whereas some females no doubt contributed eggs in more than one year. In 1976 most of the Red-winged Blackbird and Barn Swallow eggs were dipped in a salt (NaCl) solution for density measurement, then rinsed and dried before being returned to the nest (Manning 1979). It appeared therefore that the lower weight losses recorded that year might have resulted from the treatment. To test this hypothesis, 36 eggs of the Domestic Hen, *Gallus domesticus*, were dipped in a similar salt solution for 10 min, rinsed, and dried, then incubated for 12.2 d with 36 untreated eggs. The treated eggs lost an average of 7.4 ± 10.0 $mg \cdot egg^{-1} \cdot d^{-1}$ *more* than the untreated eggs. A further test was made in 1979 when half the eggs in 22 Red-winged Blackbird nests were dipped in a salt solution for 4 min on two different days and their weight loss measured over 4-d periods to give 53 paired-egg periods. The treated eggs lost 2.07 ± 2.17 $mg \cdot egg^{-1} \cdot d^{-1}$ less than the untreated. This difference ($P > 0.2$) is clearly insufficient to account for the variation between years, and as the same balances and techniques were used, and about the same portion of the incubation period covered in both years (Table 1), I am unable to suggest a cause other than differences in the environment, acting either directly to cause variation in the nests' microclimate or, perhaps more likely, indirectly to cause variation in shell porosity through the condition of the parent. A long severe winter may apparently increase weight loss in eggs of the Domestic Hen (Landauer 1967). The 1978 Red-winged Blackbird eggs also had a significantly greater variance than did the 1976 and 1979 eggs ($P < 0.05$). The difference may be associated with the greater mean, as the coefficients of variation for the three years were similar (Table 2). The variance of the 1978 Barn Swallow eggs was also

TABLE 2—Estimated mean fresh egg weight, mean daily loss of weight by eggs during incubation (with coefficient of variation (CV)), length of incubation period (LIP), and weight loss during incubation as a percentage of fresh egg weight (WLI). Species are listed in order of fresh egg weight

Species	Egg-days	N	Fresh egg weight,[a] g	Mean weight loss ± SE,[b] $mg \cdot egg^{-1} \cdot d^{-1}$	CV[a]	LIP, d	WLI, %
American Bittern	58	8 eggs	31.9 (36)	202.4 ± 10.42	14.6	24	15.2
Common Snipe	103	15 eggs	16.6 (16.0)	130.0 ± 5.55	16.5	20	15.7
Killdeer	206	19 eggs	14.2 (14.5)	67.1 ± 3.55	23.1	25	11.8
Wilson's Phalarope	55	4 eggs	9.5 (9.4)	50.2 ± 0.91	3.6	21	11.1
Sora	493	18 lots	9.0 (8.9)	61.0 ± 3.09	21.5	18	12.2
Common Grackle	89	10 eggs	6.71 (—)	61.2 ± 6.11	31.6	13	11.8
American Robin	176	26 eggs	6.36 (6.25)	75.0 ± 5.23	35.6	13	15.3
Red-winged Blackbird (North Point 1975)	914	29 clutches	4.31 (—)	53.8 ± 2.09	20.8	11.2	14.0
Red-winged Blackbird (Merrickville 1976)	397	59 eggs	4.10 (—)	45.9 ± 1.85	30.9	11.9	13.3
Red-winged Blackbird (Merrickville 1978)	460	67 eggs	3.90 (—)	57.3 ± 2.24	32.0	11.5	16.9
Red-winged Blackbird (Merrickville 1979)	518	78 eggs	4.05 (—)	48.6 ± 1.46	26.6	12.2	14.6
Savannah Sparrow	146	4 clutches	2.18 (—)	33.4 ± 4.48	26.8	11	16.9
Eastern Phoebe	94	9 eggs	2.13 (2.12)	22.6 ± 4.31	57.4	16	17.0
Barn Swallow (North Point 1975)	116	3 clutches	2.01 (1.85)	15.1 ± 2.97	34.1	15	11.3
Barn Swallow (Merrickville 1976)	440	44 eggs	1.97 (1.85)	16.8 ± 0.69	27.1	15	12.8
Barn Swallow (Merrickville 1978)	296	31 eggs	1.92 (1.85)	22.8 ± 1.12	27.4	15	17.8

[a]The figures in parentheses are taken for comparison from Schönwetter (1971–1979).

[b]The standard error and coefficient of variation for the Red-Winged Blackbird (North Point), Barn Swallow (North Point), and Savannah Sparrow are based on clutch means, those for Wilson's Phalarope on eggs within a single clutch, and those for the other species on the total variance of eggs and clutches.

greater, though not significantly so ($P > 0.05$), and the coefficients of variation are again similar.

Partition of Variances and Coefficient of Variation (CV)

The Red-winged Blackbird and Barn Swallow variances, partitioned in Table 3 into egg and clutch components are the within-year variances of Table 2. Judged by the standard errors, the percentages of the variance components do not differ significantly among the six species listed in Table 3. Their means weighted according to the degrees of freedom for eggs and clutches, respectively, are 62.6% for eggs and 37.4% for clutches. The unweighted means are similar, 62.2 and 37.8%. The clutch components are therefore low when compared with those (85.0 ± 7.8% and 56.5 ± 18.1%) for the related measurement, water vapor permeability, of eggshells of the Black-billed Magpie, *Pica pica*, and the Yellow-headed Blackbird, *Xanthocephalus xanthocephalus*, respectively (Sotherland et al. 1979, with my standard errors), but the difference appears to be significant only in the former.

Most of the personal and instrumental error, which may be relatively large owing to the small changes in weight measured under field conditions, is probably segregated in the egg component of weight-loss variance. Segregation of error will not, however, be complete as all eggs in the clutch were weighed during the same visit. The CVs given below indicate that the variation in shell porosity, both of genetic and environmental origin (Landauer 1967), is a large contributor to the total weight-loss variance and it may be expected to affect both egg and clutch components. Differences among nests in the humidity of their microclimate, caused by variation in parental behavior and weather conditions presumably affects only the clutch component.

The mean of the CVs (Table 2) that are based on total variance of eggs and clutches, when weighted by the number of eggs or lots, is 28.7 (n = 384). I am not aware of any published CVs for weight loss, but the weighted mean CV for eggs of two species of gulls, calculated for comparison from Morgan et al. (1978, Table 2), is 23.7 (n = 31), and for five species of terns, calculated from Rahn et al. (1976, Table 4), is 26.0 (n = 227). The corresponding CVs for water vapor conductance derived, respectively, from Morgan et al. (1978, Table 1) and Rahn et al. (1976, Table 2) are 21.8 (n = 29) and 18.6 (n = 78). The CVs for shell permeability of the Black-billed Magpie and Yellow-headed Blackbird derived from Sotherland et al. (1979, Table

TABLE 3—Partition of weight-loss variance into egg and clutch components with percentages of total variance and coefficients of variation (CV). Species in order of egg weight

Species and component	df	Variance (95% confidence limits), mg		% of total variance ± SE	CV
Common Snipe					
Eggs	11	261	(143–613)	56	12.4
Clutches	3	201*	(0.0–3690)	44 ± 30.1	10.9
Killdeer					
Eggs	14	129	(66–302)	54	16.9
Clutches	4	111**	(5.5–1218)	46 ± 26.1	15.7
Sora					
Eggs	11	126	(60–337)	73	18.4
Clutches	6	46**	(5.5–274)	27 ± 12.8	11.2
American Robin					
Eggs	18	424	(234–889)	60	27.5
Clutches	7	287**	(5.1–1604)	40 ± 21.7	22.6
Red-winged Blackbird (1976, 1978 and 1979)					
Eggs	146	141	(114–181)	61	23.4
Clutches	55	89****	(51–157)	39 ± 7.6	18.6
Barn Swallow (1976 and 1978)					
Eggs	58	18.6	(13–28)	69	21.8
Clutches	15	8.5***	(2.3–26)	31 ± 13.3	14.7

* = $P < 0.05$.
** = $P < 0.025$.
*** = $P < 0.005$.
**** = $P < 0.001$.

1) are 52.8 (n = 28) and 26.1 (n = 28), respectively. Ar et al. (1974) give the means and standard deviations for water vapor conductance of eggshells of 29 species of birds, ranging in size from House Wren, *Troglodytes aedon*, to Ostrich, *Struthio camelus*. The weighted mean of the CVs calculated from these figures is 28.2, but as the standard deviations appear to be derived from differences among eggs and differences among six to eight measurements per egg, the real figure is probably larger. These high CVs indicate that a large variation in weight loss can be tolerated and is presumably advantageous in a variable environment. At the same time it has been shown in at least five species (Wangensteen et al. 1974; Carey et al. 1977; Packard et al. 1977; Sotherland et al. 1980) that natural selection can act to induce changes in water vapor conductance of eggshells of high altitude populations, so that the average weight loss/fresh egg weight ratio is similar to that of their sea level counterparts. Whether such adapted populations show reduced variability or skewed distributions does not appear to have been investigated.

Relationship between Weight Loss, Fresh Egg Weight, and Length of Incubation

The regression coefficient for the exponential curve of daily weight loss (L) on fresh egg weight (W) for the 11 species recorded in Table 2 is 0.706 ± 0.0934 (r = 0.930). This does not differ significantly ($P > 0.05$) from 0.742, the figure given by Drent (1970) for 46 species. The regression equation for our combined data, using means when the data for a species are duplicated, is $L = 0.0153W^{0.723 \pm 0.0255}$ (n = 56; r = 0.968). The reduced major axis (RMA) equation is $L = 0.0143W^{0.747 \pm 0.0255}$. The standard errors of the exponents in these two equations are much smaller than the figure (0.22) given by Drent (1970). The latter was calculated according to one of the formulas of Feldstein and Hersh (1935), evidently Formula 6, which omits $(n - 2)^{1/2}$ from the denominator. The correct standard error is ± 0.0293 and therefore, contrary to what Drent supposed, the exponent in his equation is, as in the two equations above, significantly different ($P < 0.02$) from 0.667, the figure expected if the rate of weight loss varied according to egg surface area. More recently Rahn and Ar (1974) have shown that the daily weight loss varies not only with fresh egg weight but also with length of incubation to make the total weight lost during incubation a relatively constant fraction of fresh egg weight. The unweighted mean of the percentages of the fresh egg weights lost during incubation for the 11 species in Table 2 is 14.1 ± 0.64. This figure is similar to 14.3 ± 0.52, the mean for seven species of tern (Rahn et al. 1976), 15.6 for two species of gull (Morgan et al. 1978), and 15.2 for the Laysan Albatross, *Diomedea immutabilis* (Fisher 1969), but well below the 18% estimated by Rahn and Ar (1974) from their Equation 5 as an average for all eggs irrespective of weight and length of incubation period. Their equation was, however, based on two regressions, and, as all the variables were subject to error, RMAs give a more exact relationship (Kermack and Haldane 1950; Ricker 1973). When RMA values are substituted for those of regression, the equation becomes

$$F = \frac{0.014W^{0.75} \cdot 11W^{0.25}}{W^{1.00}} = 0.15$$

where W is the fresh egg weight and F the fraction of that weight lost during incubation. The exponents in the numerator of the equation now add up to 1 instead of 0.96 in the equation based on regressions, the Ws cancel out exactly instead of approximately and F is reduced from 0.18 to 0.15 or 15%. Rahn et al. (1979) obtained the same figure by the regression of total weight loss during incubation on fresh egg weight, using eggs of 65 species and a wide range of egg size and incubation length. Though they give neither the regression equation nor the correlation coefficient, it is clear from their plot that the latter is very high and the difference between regression and RMA therefore negligible. The RMA exponential equation for the 11 species listed in Table 2 is $L \cdot I = 0.153W^{0.95 \pm 0.052}$ (r = 0.987), where L is the length of incubation and I the daily weight loss. As the exponent does not differ significantly from 1, the weight loss during incubation is again 15% of fresh egg weight and the RMA a straight line on natural scale, the equation being $L \cdot I = -0.116 + 0.152 \pm 0.0073W$ (r = 0.990). The difference between the RMA coefficient and the mean (0.141 ± 0.0064) of the ratios, given as percentages in Table 2, is not significant in this small sample.

It should be noted that the term 'total weight loss during incubation' has been used but no allowance made for the extra rate of weight loss after pipping. As the crucial factor is probably the size of the airspace in the egg just before pipping (Rahn and Ar 1974), it would be better to consider only the period up to that point, but its length is not available for most species.

Acknowledgments

I am grateful to the Canadian Wildlife Service and particularly to S. G. Curtis and R. I. G. Morrison for the opportunity to work at North Point in 1975. I was ably assisted at North Point by Mitchel Thomlison, who found many of the nests and recorded all my measurements. Pamela M. Morse, though in no way responsible for the results, gave valuable statistical advice, and Henri Ouellet and three reviewers made helpful comments on the first draft of the manuscript.

Facilities for incubation of the hens' eggs were provided at the Animal Diseases Research Institute, Ottawa, through the courtesy of K. J. Betteridge.

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Received 3 May 1977
Accepted 5 June 1980

Sex Differential in Use of the Physical Environment by Bighorn Sheep (*Ovis canadensis*)

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Morgantini, Luigi E., and Robert J. Hudson. 1981. Sex differential in use of the physical environment by Bighorn Sheep (*Ovis canadensis*). Canadian Field-Naturalist 95(1): 69–74.

The use of the physical environment by Bighorn Sheep (*Ovis canadensis*) rams and ewes on a common winter range in western Alberta showed sex differential in habitat selection and spatial distribution. In winter ram groups occurred on more steep and rocky ground and were found closer to forests than ewe groups. In spring habitat selection of rams did not change, whereas ewes shifted to lower elevations and onto more steep and rocky habitats. During this season segregation between the sexes was ensured through the use of two distinct sections of the available range. These results, when compared with other studies, do not support previous hypotheses explaining sex segregation in Bighorn Sheep. A new hypothesis, that spatial separation maximizes individual fitness by reducing energy-expensive sexual-agonistic behavior in rams at times when reproduction is not possible, is proposed.

Key Words: Bighorn Sheep, *Ovis canadensis*, habitat selection, sex segregation.

Habitat and spatial separation in winter between Bighorn Sheep (*Ovis canadensis*) rams and ewes on the Palliser range in Banff National Park has been studied extensively by several authors (Geist and Petocz 1977; Shank 1979). Although the significance of such sex segregation is not clear, three hypotheses have been proposed. Geist and Petocz (1977) have interpreted habitat separation between rams and ewes as a behavioral pattern evolved to minimize intraspecific competiton. Bromely (1977) and Geist and Bromely (1978) have explained segregation of males from females in winter as an anti-predator strategy. Recently, Shank (1979) hypothesized that ecological separation between the sexes in Bighorn Sheep simply reflects different body sizes and, therefore, different habitat requirements (Shank 1979).

This study was undertaken to determine whether habitat and spatial separation between rams and ewes occurred in another geographical region, the Ya Ha Tinda Ranch area, where the two sexes share a common winter range. In the event that sexual segregation did occur, the second objective of the study was to assess whether the results supported any of the preceding hypotheses.

Study Area

The study area is located in western Alberta in the foothills of the Rocky Mountains, about 10 km east of the eastern boundaries of Banff National Park (51°45′–46′N, 115°33′–35′W). It consists of south-facing, largely open slopes situated north of the Ya Ha Tinda Ranch valley, one of the most important Elk (*Cervus canadensis nelsoni*) winter ranges in the province. Elevation varies from 1550 m on the valley floor to 2400 m on higher slopes. The area enjoys a relatively mild climate. As a result of the effect of the surrounding mountains on airflows, cloud cover does not develop to the extent that it does over the surrounding areas, and western winds keep the grassland and open slopes largely snow-free (Morgantini 1979).

The vegetational characteristics of the mountain slopes have been described by Gates (1975). At high elevation (above 2074 m), Hairy Wild Rye (*Elymus innovatus*) is the predominant grass species. Sedges make up 40% of the floristic composition. At lower elevation, Northern Wheat Grass (*Agropyron dasystachyum*), Purple Reed Grass (*Calamagrostis purpurascens*), and June Grass (*Koeleria cristata*) are the dominant species in descending order of frequency of occurrence. Forests of Trembling Aspen (*Populus tremuloides*), Lodgepole Pine (*Pinus contorta*), and spruce (*Picea glauca* and *Picea engelmannii*) also are found (Morgantini 1979).

The study area is an important Bighorn Sheep winter–spring range. At the time of this study it supported a population of some 80 individuals.

Methods

From December 1975 to May 1976 data were collected by direct observation of activity, movements, and behavior of Bighorn Sheep, conducted from vantage points situated on the valley floor. Once a group of animals was sighted, time, number of individuals, sex, and, if possible, age were recorded. Each location was marked on a low oblique aerial photograph to within 5 m so that it could be easily located for subsequent description of its physiographic characteristics. Emphasis then was placed on behavioral observations for as long as the animals could be observed. In several instances movements of the same herd, identified by

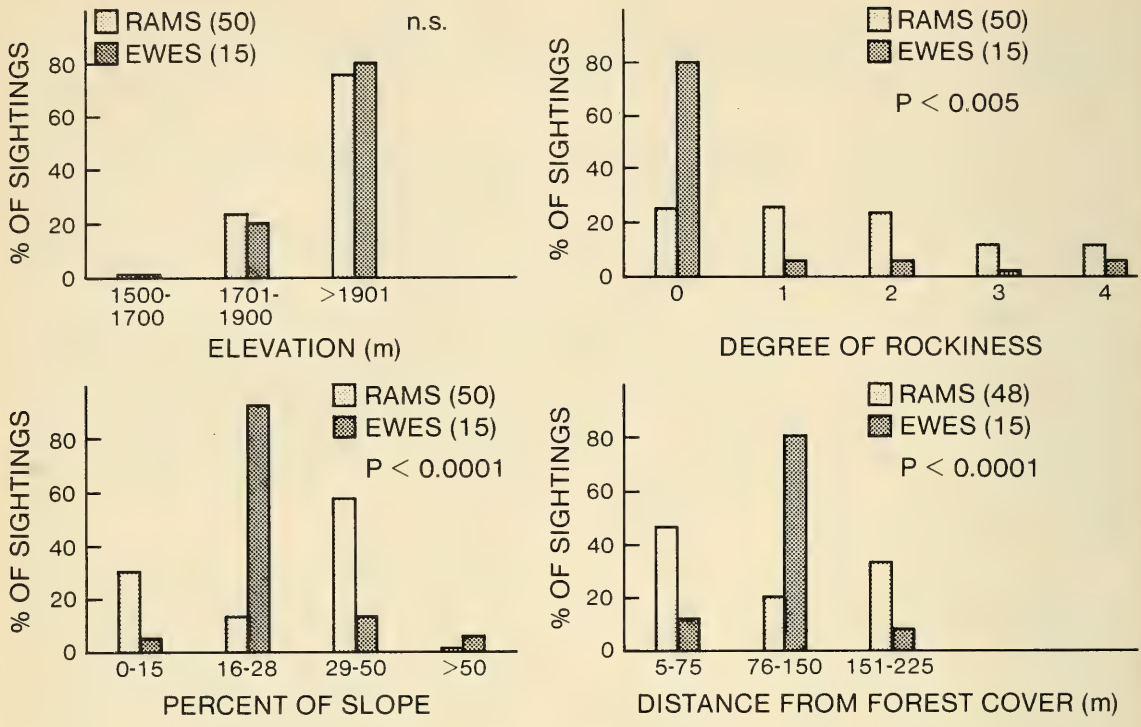

FIGURE 1. Comparison of distribution of Bighorn Sheep ram and ewe groups in winter as measured by elevation, percentage of slope, degree of rockiness, and distance from forest cover (total number of group sightings in parentheses).

its structure and by the characteristics of individuals, could be recorded for several consecutive days. Each month from 15 to 20 d were spent in the field.

To detect seasonal changes in distribution, we subdivided observations into two groups: winter observations, from December through 15 March, and spring observations, from 16 March through May. The beginning of the spring season was placed at the time when the first new plant growth was observed.

Seven abiotic environmental parameters were considered as potential determinants of animal distribution on open ranges. They were slope (percent), aspect (degrees), elevation (metres), rockiness (scores 0–4), distance to forest cover (metres), snow depth (centimetres), and snow cover (percent). With the exception of distance to forest cover estimated from aerial photographs, environmental variables were measured directly in the field. At the end of the study, aspect was discarded because it was found to change little within the study area.

To assess sex differences in spatial distribution, the study area was arbitrarily subdivided in three sections, using the North–South lines of the Universal Transverse Mercator (UTM) grid system.

During the study period, 151 group sightings were made. These comprised a total of 2035 animal observations. Group sightings were placed in three categories termed "rams," when the group was composed only of adult or subadult males; "ewes," when the group was composed of adult females and subadults, either females or males; "mixed," whenever mature males, class II rams (Geist 1971), were present in a "ewes" group. The response of animals to physiographic factors was assessed on the basis of percentage of group sightings. Seasonal changes in occupational patterns were determined by comparing frequency distributions using chi-square contingency table analyses.

Results

In winter, both ram and ewe groups were found mostly on high elevation ranges. However, ewes were generally observed farther from forests and on less steep and rocky ground (Figure 1).

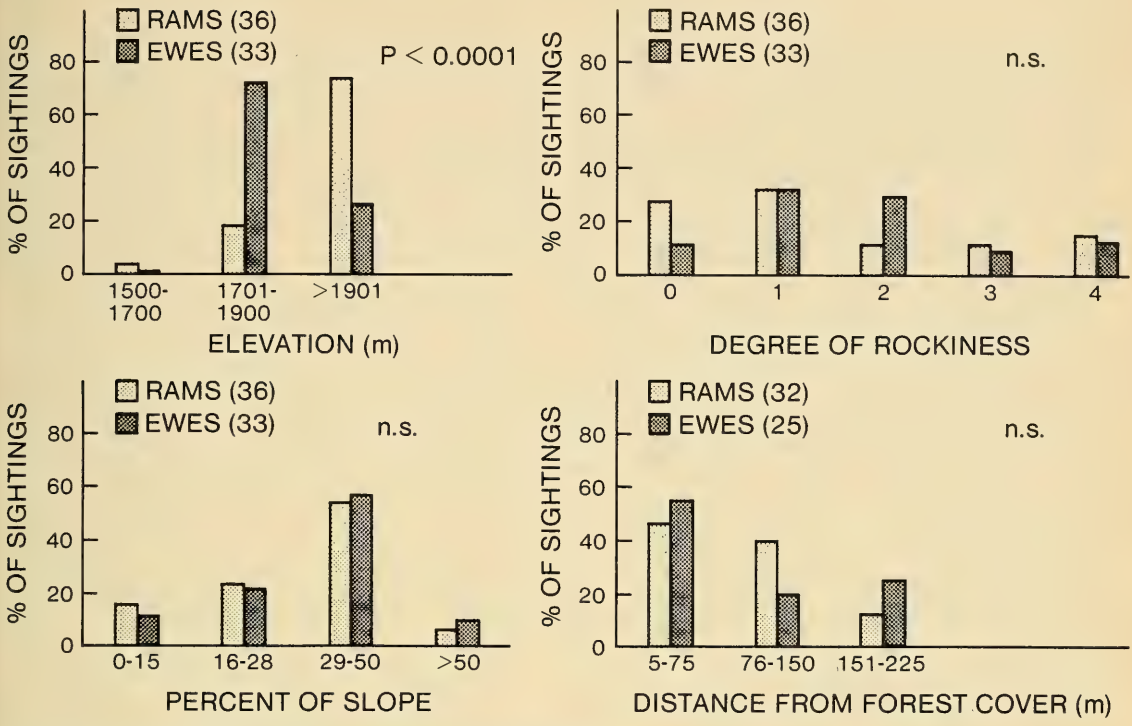

FIGURE 2. Comparison of distribution of Bighorn Sheep ram and ewe groups in spring as measured by elevation, percentage of slope, degree of rockiness, and distance from forest cover (total number of group sightings in parentheses).

Snow cover and depth were not found to be significant in determining daily or monthly distribution on open ranges, possibly because of mild winter conditions. In several instances the same herds could be still found the day after snow storms grazing on the same sites on medium and high elevation ranges.

In spring, the distribution of rams did not change (Figure 2), while ewes shifted to lower elevations ($P < 0.001$) and onto more rocky ($P < 0.0002$) and steep ($P < 0.006$) ground. In spring, ewes were also observed closer to forest cover.

With regard to spatial distribution, ram groups were generally found on the east section of the range (Figure 3). This section is separated from the central section by a timbered draw about 250 m wide, and, compared to the other sections, is generally more rocky and steep, with cliffs and talus slopes interspersed with patches of vegetation. Selection of this area by rams was particularly evident during the spring months and coincided with a shift by ewes to lower elevations onto the main, central range.

During the study period, we observed 6 mixed groups in winter and 11 in the spring. They were generally found at lower elevations than either ram or ewe groups. In their response to rockiness, slope, and distance from forests, they appeared intermediate to rams and ewes. No seasonal change could be detected in the distribution of mixed groups. These comparisons may not be valid, however, because of the small sample size.

Discussion

A difference in distribution between ram and ewe groups was found. In winter, habitat separation occurred on the basis of rockiness, slope, and distance from forests. In spring, elevation was the main factor. The seasonal difference is attributable to the shift of ewes in spring to lower elevation and onto more rocky and steep ground. This shift may possibly indicate a more intense search for high-quality forage caused by greater nutrient requirements during pregnancy. For instance, heat retention by rocks during sunny days in late winter and spring may have produced warmer microclimatic conditions favorable to earlier forage growth and higher nutrient content as compared to adjacent grassy areas. Similarly, the degree of slope may affect forage quality by influencing the amount of solar radiation reaching the ground. Although the

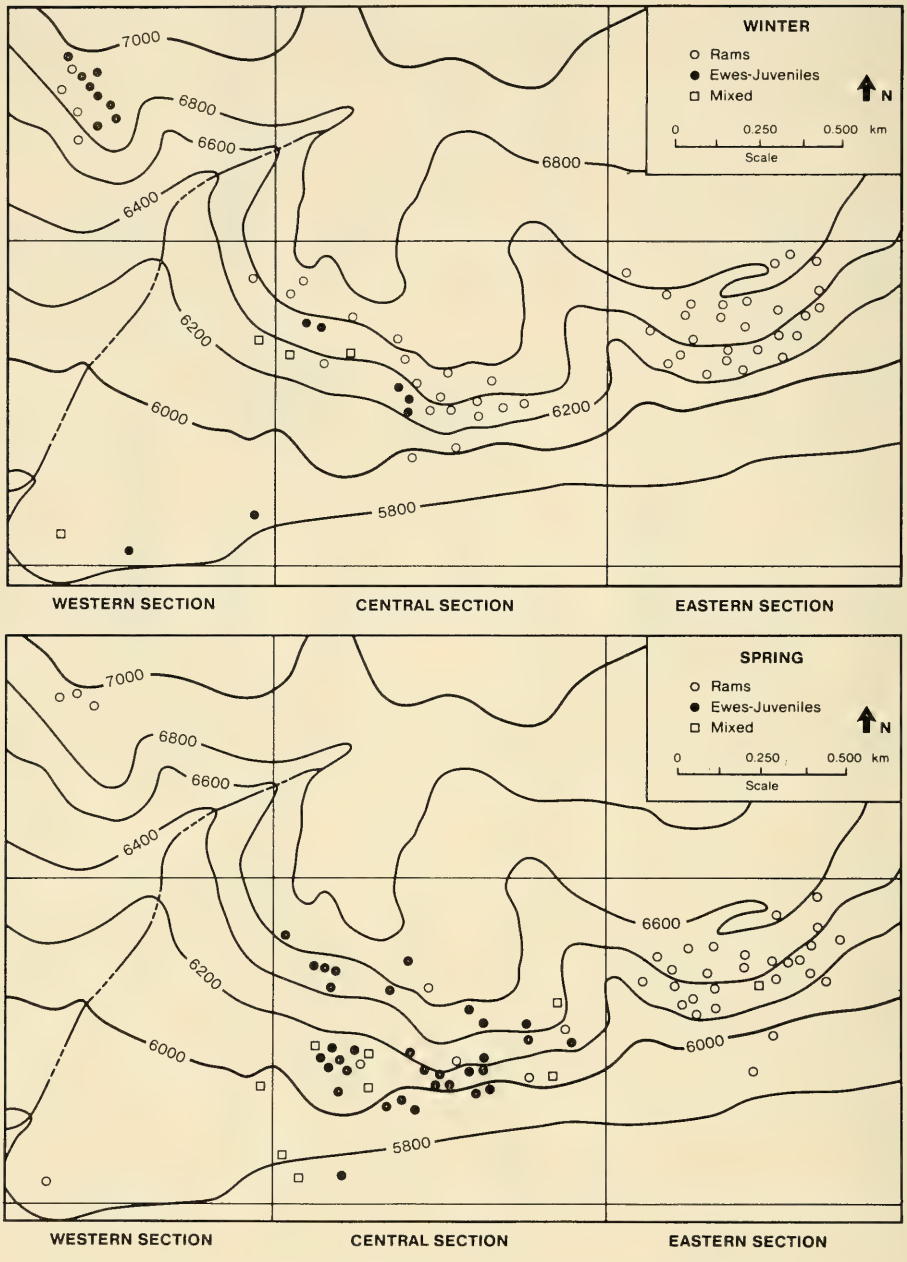

FIGURE 3. Locations of Bighorn Sheep ram, ewe, and mixed groups in winter and spring.

preceding hypotheses are speculative, they are supported by observations of highly selective foraging behavior in Bighorn Sheep (Hebert 1973; Shannon et al. 1975). Alternatively, spring occupation by ewes of more steep and rocky ground could be interpreted as an anti-predator strategy at a time when animals were in poor physical condition (Shank 1979). It is worth noting that the only case when ewes were observed on a steep cliff in winter was in response to an unsuccessful hunt by a Cougar (*Felis concolor*).

The behavior of Bighorn Sheep on the Ya Ha Tinda range suggests that both habitat and spatial factors contributed to the separation of the sexes. In winter, when ram and ewe groups were not spatially separated, i.e. geographically separated, they used different habitats. In spring, when such differences were limited to the elevational gradient, the two sexes were spatially separated and restricted to two distinct sections of their range.

This study in itself does not lend much insight to the significance of sex segregation in Bighorn Sheep. When the results are compared with other studies, however, an assessment of previous hypotheses explaining this phenomenon may be made.

Essentially three hypotheses can be distinguished. In the first hypothesis, ecological separation between the sexes is thought to reflect differences in body size and, therefore, different behavioral patterns and habitat requirements. The hypothesis has been extensively developed by Shank (1979); however, if differences in habitat selection between rams and ewes simply reflected their differences in body sizes, we would expect to find, for the same sex, similar habitat requirements or, at least, similar adaptive strategies, in diverse environments. This is not indicated in our study. We found that in winter, rams selected rockier and steeper ground than ewes. A different behavior was recorded by Geist and Petocz (1977) on the Palliser range in Banff National Park. They reported a preference by rams for grassy slopes and by ewes for rocky habitats. This difference between the sexes in habitat preferences was partially explained on the basis of snow accumulation patterns on slopes. Rams, being larger and heavier than ewes, could still graze on snow-covered slopes, whereas ewes had to move to relatively snow-free cliffs. Lack of deep snow and mild climatic conditions during our study may account for the occurrence of ewes on grassy slopes in winter. However, Geist and Petocz's explanation suggests that rams, which in one environment brave deep snow to graze on grassy slopes, will remain on snow-free slopes in other ranges. As shown, this does not occur on the Ya Ha Tinda range. Further, according to Shank (1979), the utilization by ewes of cliffs and rocky habitats reflects a higher ". . . susceptibility to predation as determined by body size" (p.127). This implies a sex-specific habitat selection strategy that should maximize security. Yet, the winter distribution of ewes in our study area does not indicate any distinct anti-predator strategy. In conclusion, it appears that, on both the Palliser and the Ya Ha Tinda range, the two sexes simply tend to separate and that such a separation takes a different form depending on the environmental conditions of their common winter range. This intersexual avoidance is further indicated in our study by the decreased number of sightings of rams on the main, central range in spring, at the time when ewes had begun to use it (Figure 3).

The second hypothesis suggests that the segregation of males from females has evolved as anti-predator strategy. Males, exhausted by the breeding season and easily distinguishable from females, would be subjected to selective predation during winters, unless they avoid females or shed their sign of maleness as do Pronghorns (*Antilocapra americana*) (Geist and Bromely 1978). On the Ya Ha Tinda range we observed rams and ewes restricted to a relatively small winter range with rams strongly associated with a particular section. Such a preference by rams has been observed for three subsequent seasons (1976–1979) (L. E. Morgantini, personal observation). If predator avoidance had shaped the sex-segregation behavior of Bighorn Sheep, we would not expect rams to restrict activity to specific limited areas where they could be easily located by predators, unless those areas provided high-quality escape terrain. But this was not indicated in our study. Furthermore, even though the ram section was somewhat more rocky and steep, rams were generally found closer to forests than ewes (Figures 1 and 2) and always reacted to approaching humans or predators, regardless of their direction, by escaping west, throughout the timbered draw, across the main open slope to the higher elevation ranges.

The third hypothesis, proposed by Geist and Petocz (1977), suggests that males avoid females in winter to minimize intraspecific competition. That is, to maximize reproductive fitness, ". . . males ought not to compete with their own offspring during ontogeny, nor with the prospective mothers of their offspring" (p. 1803). Basically this hypothesis is an extension of a hypothesis first proposed by Rand (1952), who noted that ecological segregation between the sexes, different food habits, and sexual dimorphism could be seen as adaptations to reduce intraspecific competiton. Our results, however, are not consistent also with this hypothesis. With regard to competition by exploitation, our data show that in spring ewes selected habitats and areas that had been previously used by rams. Although Shank (1979) reported differences in food habits between the sexes, such differences were attrib-

uted by the author to the use of different areas. Further, diet quality, as assessed by fecal protein analysis, differed only 'marginally' (Shank 1979). It is therefore difficult to see how, in our study area, previous use of the ranges by rams could be advantageous to breeding females. Yet, because the sexes are separated, minimization of intraspecific competition by interference, that is, low harassment of ewes by rams, may be occurring. However, in addition to the theoretical problems reviewed by Shank (1979), the hypothesis of competition minimization presented by Geist and Petocz (1977) implies the presence of sex-linked (Whitney 1976; Wickler 1977) altruistic behavior (Hamilton 1964). To not "compete" with ewes, rams would risk reducing their own reproductive potential by using alternative, possibly suboptimal habitats.

On the basis of our results we think that maximization of individual fitness by rams is all that is required to explain the evolution of sex segregation in Bighorn Sheep and that there is no need to invoke, directly or indirectly, altruistic behavior or kin selection. In fact, it can be expected that the occurrence of rams with ewes in mixed herds after the end of the breeding season would cause a higher frequency and intensity of sexual and agonistic behavior among rams, and consequently higher energy expenditures at times when reproduction is not possible. Such higher energy expenditures could be particularly detrimental during harsh winters. It is therefore possible that, to minimize energy expenditures associated with sexually related social interactions, the coexistence of males with females in periods other than the breeding season was selected against, and that it is avoided through habitat and spatial separation. In this context, different physiological and/or behavioral requirements are expected to shape habitat preferences that adjust to local environmental conditions. This hypothesis is consistent with our data and with the present knowledge of social behavior of Bighorn Sheep (Geist 1971). It accounts for the fact that rams leave rutting ranges first; that older rams, for which sexual agonistic behavior is more energy demanding, stay on rutting ranges for shorter periods of time than younger ones; and that generally the occurrence of rams in ewe groups is inversely correlated with their age (Geist 1971; Geist and Petocz 1977). In our hypothesis, minimization of intraspecific competition, predators avoidance, or sexual dimorphism-related niche differences could be all seen as by-products of the avoidance by rams of sexual-agonistic stimuli outside the rutting season.

Acknowledgments

We acknowledge the cooperation of the Alberta Fish and Wildlife Division for financial and logistic support, the Department of Zoology of the University of Alberta for equipment, and Parks Canada for permission to conduct the study on the Ya Ha Tinda Ranch. We are also grateful to Raffaella Morgantini for many helpful discussions and her assistance in the field, and to the staff of the Ya Ha Tinda Ranch (Slim Haugen, Earl Hays, and Gordon Patterson) for their cooperation throughout the field work.

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Received 25 February 1980
Accepted 12 August 1980

Terrestrial Molluscs of Central Alberta

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Van Es, James, and D. A. Boag. 1981. Terrestrial molluscs of central Alberta. Canadian Field-Naturalist 95(1): 75–79.

The litter from forest habitats dominated by *Populus* spp. was sampled within a 100-km radius of Edmonton, Alberta, and searched for the presence of terrestrial molluscs. Eighteen species belonging to eight families in two orders were identified. Thirteen of these species had not been reported previously from this area. Information on distribution and abundance of these molluscs is included.

Key Words: terrestrial molluscs, distribution, size, abundance, central Alberta, *Populus*, habitat.

The terrestrial molluscan fauna of western Canada is poorly known. Mozley (1934) reported on this group of invertebrates in Saskatchewan and Alberta, listing the six families and 11 species known at that time. For each species (not all were identified beyond genus), he gave only the name of the town nearest the collection site, although in an earlier publication (Mozley 1930) he described the characteristics of some of the species (those found in Jasper National Park) in more detail. To our knowledge, these two papers, which refer to even earlier investigations (Berry 1922; Mozley 1933), remain the only publications that attempt to deal with the terrestrial molluscs of Alberta as a whole. More recently, Russell (1951) described this fauna in the Cypress Hills, and Platt (1980) and Boag (unpublished data) have added to the species list for the east slopes of the Rocky Mountains in Alberta.

As a first step in an attempt to record the distribution and abundance of terrestrial molluscs in remnants of the native vegetation of Alberta, we report here on this fauna in the vicinity of Edmonton, Alberta (Figure 1).

Methods

Forest habitats within the area shown in Figure 1 were sampled (Appendix 1) in April through June and in October 1979. At each of 31 sites (Figure 1), we took two 0.25-m^2 samples of forest litter, usually about 10 m apart and representative of the site in general. The depth of litter taken varied from 5 to 25 cm depending on the state of decay of the most recent leaf fall. Each sample was bagged, labeled, and, on return to the laboratory, dried at room temperature before being sieved and searched for the shells of snails. All specimens found were removed and placed in labeled vials. Subsequently, the snail shells were separated (on the basis of shell morphology) into the various species present, tentatively identified, and stored in separate vials. From each site sampled we randomly selected up to 25 undamaged and non-eroded specimens of each species for measuring. We used an ocular micrometer in a dissecting microscope to take the measurements.

In addition 19 forest sites were sampled by searching the litter and overturning the debris on the forest floor (Figure 1, Appendix 1). Specimens handpicked by this method were treated in a similar manner to those taken from the dried litter samples.

Specimens of each tentatively identified species were sent to the National Museum of Natural Sciences, Ottawa, where identifications were confirmed or corrected, and where the samples of these species are now housed.

Results and Discussion

At 85% (n = 50) of the sites sampled, the dominant trees were Trembling Aspen (*Populus tremuloides*) and/or Balsam Poplar (*P. balsamifera*), whereas at the remaining 15% of sites, the forests were mixed with *Populus* spp. interspersed among either conifers (White Spruce, *Picea glauca* and/or Jack Pine, *Pinus banksiana*) and/or Paper Birch (*Betula papyrifera*).

The two methods of sampling produced different results (Table 1). Handpicked samples produced significantly fewer individuals per sample site (post hoc procedure using pair-wise contrast, $P < 0.05$). Furthermore, the specimens recovered were biased significantly in favor of the largest and against the smallest species (chi-square test, $P < 0.05$). Consequently we did not use the 19 handpicked samples in any of the quantitative analyses. Handpicked samples, however, were useful in determining the presence of slugs, as they were not recovered from the litter samples, having been lost during the drying process.

In the 31 samples of forest litter, we recorded terrestrial molluscs from two orders (Stylommatophora and Basommatophora) and seven families (Zonitidae, Endodontidae, Succineidae, Pupillidae, Valloniidae, Cionellidae, and Carychiidae). Additionally, we found one species of slug in an eighth family (Limaci-

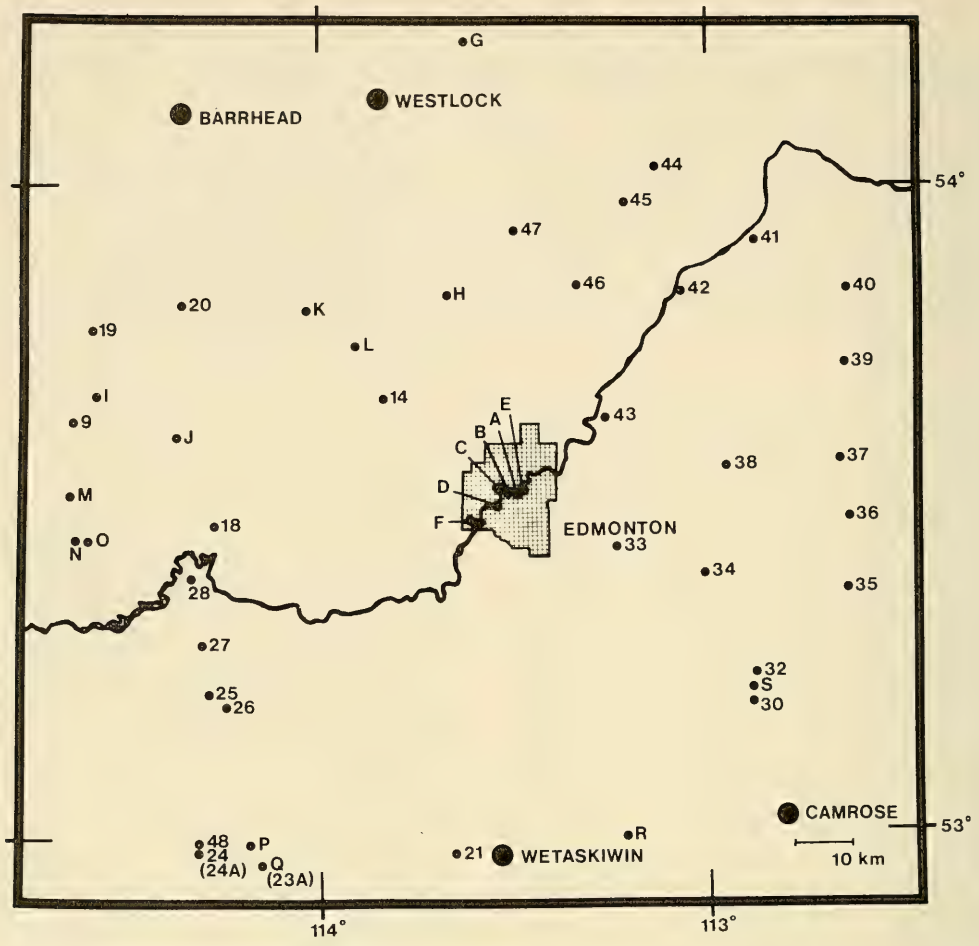

FIGURE 1. Locations where litter samples (numbers) and handpicked samples (letters) were taken in central Alberta. See Appendix 1 for descriptions of exact locations.

dae) among the handpicked samples. In all, 18 species have been identified (Table 2).

Three zonitids (*Euconulus fulvus, Retinella electrina, Vitrina alaskana*), one endodontid (*Discus cronkhitei*), one pupillid (*Vertigo gouldi*), and the only cionellid (*Cionella lubrica*) were widely distributed throughout the area and in the various forest types. Each species was present in at least 90% of the samples (Table 2). *Discus cronkhitei* and *Vertigo gouldi* were also relatively abundant at each site, averaging about 50 specimens/0.5 m² sample of forest litter (Table 2). *Vitrina alaskana* and *Cionella lubrica*, although widespread, were found at much lower densities, on average about 12 specimens/0.5 m² (Table 2). These differences may represent absolute differences in abundance or differences in rates of disappearance of the shells of the respective species. In most samples, some shells were eroded and often on the point of disintegration, the snails presumably having been dead for some time. Thus abundance figures include some shells of snails that may have been dead

TABLE 1—Relative numbers and sizes of terrestrial molluscs recovered in 19 handpicked and 31 litter samples

Size of molluscs (no. dimensions >2 mm)	Mean number of individuals	
	Handpicked samples	Litter samples
0	1.26	82.83
1	20.42	106.68
2	12.16	26.96

TABLE 2—Terrestrial molluscs recovered from 31 litter samples collected in central Alberta forests dominated by *Populus* spp. Species marked with an asterisk were previously recorded in this area by Mozley (1934)

Taxa	Measurements[a] Sample size	Height (mm) x	Height (mm) (95% conf. inter)	Width (mm) x	Width (mm) (95% conf. inter)	Frequency of occurrence (% of sites)	Number of snails per sample (0.5 m²) x	Number of snails per sample (0.5 m²) (range)	Number of snails per sample (0.5 m²) n[b]
Stylommatophora									
Zonitidae									
**Euconulus fulvus*	256	1.95	(1.90–2.00)	2.67	(2.62–2.72)	97	27.3	(1–167)	30
**Retinella electrina*	71	1.74	(1.65–1.83)	3.35	(3.20–3.50)	90	22.9	(1–77)	28
**Zonitoides arboreus*	38	2.18	(2.07–2.29)	4.27	(4.02–4.51)	42	3.1	(1–7)	13
Vitrina alaskana	152	2.38	(2.29–2.46)	4.35	(4.19–4.50)	90	11.6	(1–47)	28
Limacidae[c]									
Deroceras laeve	—	—	—	—	—	—	—	—	—
Endodontidae									
**Discus cronkhitei*	352	1.90	(1.84–1.95)	3.48	(3.39–3.58)	94	48.9	(1–266)	29
Punctum minutissimum	170	0.68	(0.67–0.69)	1.16	(1.14–1.17)	71	22.6	(1–169)	22
Succineidea									
Oxyloma sp.	4	8.83	(6.23–11.42)	4.95	(3.35–6.55)	3	4.0	—	1
Succinea sp.	11	8.96	(5.75–12.18)	5.12	(3.90–6.33)	29	2.6	(1–10)	9
Pupillidae									
Gastrocopta tappaniana	21	1.91	(1.81–2.01)	1.20	(1.19–1.21)	10	6.7	(1–18)	3
Vertigo gouldi	337	1.73	(1.71–1.75)	1.01	(1.00–1.02)	90	60.0	(1–497)	28
Vertigo modesta	3	2.40	(1.97–2.83)	1.37	(1.22–1.51)	3	3.0	—	1
Columella simplex	42	1.80	(1.73–1.87)	1.21	(1.20–1.23)	19	7.3	(2–14)	6
Valloniidae									
Vallonia gracilicosta	155	1.22	(1.21–1.23)	2.56	(2.54–2.58)	42	33.1	(2–137)	13
Vallonia sp.	85	0.86	(0.82–0.89)	1.73	(1.66–1.80)	13	74.5	(13–195)	4
Zoögenetes harpa	24	3.02	(2.91–3.14)	2.49	(2.44–2.54)	10	20.3	(1–57)	3
Cionellidae									
**Cionella lubrica*	116	5.21	(5.13–5.29)	2.41	(2.39–2.44)	94	13.7	(1–79)	29
Basommatophora									
Carychiidae									
Carychium exile	2	2.0	—	1.0	—	3	2.0	—	1

[a] Only undamaged and non-eroded specimens were measured.
[b] Mean and range are based only on samples in which at least one specimen was found.
[c] Not recovered from litter samples but only in handpicked samples (n = 19).

for a variable time period. For species like *Vitrina alaskana*, the shell of which is very fragile, disintegration time may be much shorter than for other species with stouter shells. This may explain the lower abundance of *Vitrina alaskana* despite its high frequency of occurrence in the samples. The relative acidity of the soil may also be an important factor influencing the rate of disintegration of shells.

Of the remaining species, three were reasonably common. *Zonitoides arboreus* was found in 42% of the litter samples but was never abundant, averaging 3.1 specimens per sample (Table 2). By contrast, *Punctum minutissimum* and *Vallonia gracilicosta* were both reasonably common and abundant (Table 2). The remaining nine species were neither common nor abundant, with the exception of *Vallonia* sp. which appeared in only 13% of the samples but at an average of 74.5 individuals per sample (Table 2). The distribution of *Vallonia* sp. is interesting since it was found only in samples taken northeast of Edmonton. Thus, the frequency of occurrence within the limits of the sampling area may reflect only where the samples were taken in relation to the species range rather than a measure of ubiquity within its normal range. This problem can be addressed only by more intensive sampling to determine the actual range of the species.

The species diversity at given sites varied considerably (5–14 per sample). In general the abundance of individuals was positively correlated with number of species present (5 species and 14 individuals to 14

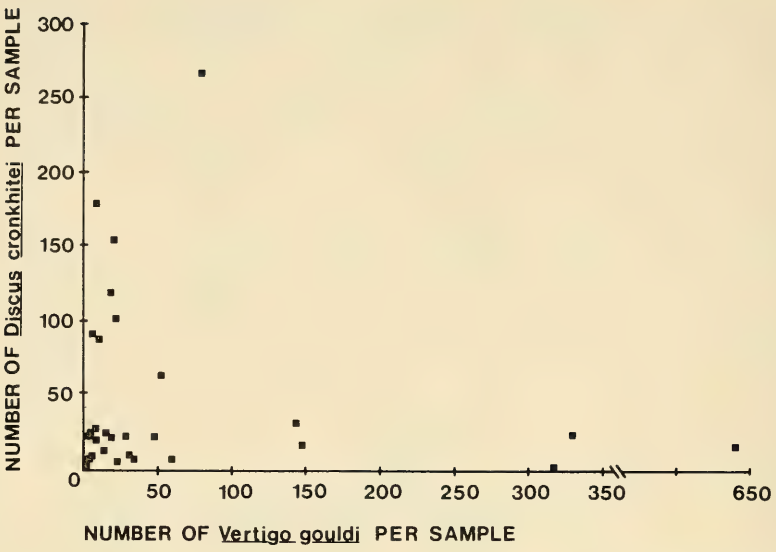

FIGURE 2. The relationship between the numbers of *Vertigo gouldi* and *Discus cronkhitei* in litter samples taken from forest habitats in central Alberta.

species and 291 individuals per sample). This relationship would seem to reflect relative richness of the habitat rather than interactions among the species. A comparison of the numbers of the two most abundant species (*Discus cronkhitei* and *Vertigo gouldi*) at each site, however, suggests some form of interaction that leaves one species dominant numerically at one site and the other at a second site (Figure 2). Where the abundance of each species was less than 50/0.5 m^2, there was no apparent difference in species abundances. When the number of individuals of each species exceeded 50, however, it appeared that either one of the two was relatively much more abundant, possibly at the expense of the other. If this is so, it may reflect some form of competitive advantage of one or other of the species in a given habitat. In this regard it is noteworthy that *Discus cronkhitei* greatly outnumbered *Vertigo gouldi* only in the southwest half of the study area whereas the converse was true only in the northeast half.

Mozley (1934) recorded the same four species of zonitids as we did (Table 2) in Alberta; however, he referred the specimens of *Vitrina* to the species *V. limpida*. He did not record the endodontid, *Punctum minutissimum*, a species we have found to be reasonably abundant. Of the succineids, he recorded only the genus *Succinea* and he referred the specimens to *S. retusa*. Among the pupillids, he recorded neither the genus *Gastrocopta* nor *Columella* in Alberta but did record *Vertigo*; however, he referred these specimens to the species *V. ovata*. Of the valloniids, he recorded neither *Vallonia gracilicosta* nor *Zoögenetes harpa*. It is not surprising for the latter as we have found it infrequently and then only in the southwest corner of the area surveyed. Mozley (1934), however, did record *Vallonia costata*, a species which we have not found. We are unable to comment on the differences in the species identified as we have not seen Mozley's (1934) material. Mozley (1934) recorded neither the limacid, *Deroceras laeve*, a species apparently widespread in the province (Platt 1980; Boag, unpublished data) nor the terrestrial basommatophoran, *Carychium exile*.

Acknowledgments

We are pleased to acknowledge the stimulus provided by A. N. Spencer, who initially suggested this study; the logistic help received in the field from R. Seward and R. Mandryk; the statistical advice and analyses completed by A. Wroot; and the confirmation of identification of the molluscs by M. F. I. Smith.

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Received 29 March 1980
Accepted 29 May 1980

APPENDIX I—Locations at which samples were collected in the vicinity of Edmonton, Alberta

Sample site[a,b]	Location	Forest cover
9	3.3 km N of Fallis Point	Poplar
14	1.6 km W of Villeneuve	Poplar
18	2.1 km N of Mewassin	Poplar
19	12 km N of Darwell	Poplar
20	9.1 km N of Gunn	Poplar
21	Highway 2 S at Pigeon Lake turnoff	Mixed forest
23A	South end of Battle Lake	Willow
24	7.5 km E of Winfield	Mixed forest
24A	7.5 km E of Winfield	Mixed forest
25	4.5 km NE of Warburg	Poplar
26	2.5 km W of Sunnybrook	Mixed forest
27	11.6 km N of Warburg	Poplar
28	6.6 km N of Genesee	Poplar
30	4.1 km S of Miquelon Lakes	Poplar
32	Miquelon Lakes Provincial Park	Poplar
33	Junction Highway 14 and Highway 21	Poplar
34	Ministik Campground	Mixed forest
35	0.8 km E of Tofield	Poplar
36	13 km N of Tofield	Poplar
37	Junction Highway 16 and Highway 834	Poplar
38	West Baseline Elk Island Park, where Highway 16 passes through	Poplar
39	3.1 km N of Chipman	Poplar
40	1.6 km W and 0.8 km N of St. Michael	Mixed forest
41	1.6 km W and 2.3 km N of Deerland	Poplar
42	8.3 km N of Scotford	Poplar
43	5 km N and 1.6 km W of Akenside	Poplar
44	8.6 km N and 1.6 km W of Redwater	Poplar
45	2.5 km S of Opal	Poplar
46	1.6 km N and 1.6 km W of Gibbons	Poplar
47	7.5 km E and 3.3 km S of Legal	Poplar
48	7.5 km E and 1.2 km N of Winfield	Poplar
A	South Bank N. Saskatchewan River, Edmonton, near Highlevel Bridge	Poplar
B	South Bank N. Saskatchewan River, Edmonton, near University of Alberta	Poplar
C	South Bank N. Saskatchewan River, Edmonton, West of Groat Bridge	Poplar
D	South Bank N. Saskatchewan River, Edmonton, near Whitemud Creek	Poplar
E	South Bank N. Saskatchewan River, Edmonton, near Highlevel Bridge	Poplar
F	South Bank N. Saskatchewan River, Edmonton	Poplar
G	8.3 km NE of Clyde Corner	Poplar
H	1.6 km W and 3.3 km N of Morinville	Poplar
I	0.8 km E of Darwell	Poplar
J	9.1 km S of town of Alberta Beach	Poplar
K	Sandy Lake, near campground	Poplar
L	6.6 km S of Alexander Indian Reserve	Poplar
M	3.3 km W and 1.6 km S of Sundance	Poplar
N	8.3 km W of Highvale	Poplar
O	6.6 km W of Highvale	Spruce bog
P	4.1 km NW of town of Battle Lake	Mixed forest
Q	South end of Battle Lake	Willow
R	South end of Coal Lake	Poplar
S	1.6 km S of Miquelon Lakes	Poplar

[a] See Figure 1 for positions of numbers and letters.
[b] Numbers refer to leaf litter samples (n = 31). Letters refer to handpicked samples (n = 19).

Deer Mortality in the Pohénégamook Wintering Area, Quebec

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Potvin, François, Jean Huot, and François Duchesneau. 1981. Deer mortality in the Pohénégamook wintering area, Quebec. Canadian Field-Naturalist 95(1): 80–84.

From 1972 to 1979 a study was conducted in the Pohénégamook wintering area to identify the major factors responsible for mortality of White-tailed Deer (*Odocoileus virginianus*) under severe environmental conditions. Aerial surveys, pellet-group counts, and dead-body surveys were used to monitor the population every year and to estimate the natural mortality. During the period of the study the population decreased from 480 to 140 deer, a 71% decline. This resulted from very high winter mortality rates which in some years exceeded 40%. The most severe winters were those of 1975 and 1977 when snow depth was more than 50 cm during almost the entire season. We estimated that respectively 200 and 120 deer died in these winters. Death by starvation was the highest of all winter mortalities of known causes. Most of the 121 mortality cases during the study were fawns or adult females. We suggest that these heavy mortality rates result from extremely severe winter conditions, in the presence of available food, rather than from "over-population."

Potvin, François, Jean Huot, and François Duchesneau. 1981. Deer mortality in the Pohénégamook wintering area, Quebec, Canadian Field-Naturalist 95(1): 80–84.

De 1972 à 1979, le ravage de Pohénégamook servit de cadre à une étude entreprise dans le but d'identifier les facteurs de mortalité du cerf de Virginie (*Odocoileus virginianus*) dans des conditions extrêmes d'environnement. Des inventaires aériens, des dénombrements de tas de fèces et des inventaires de carcasses ont permis de suivre la population d'année en année et d'estimer la mortalité naturelle. Au cours de la période, la population est passée de 480 à 140 cerfs, soit une baisse de 71%. Ce déclin fut provoqué par des taux de mortalité hivernale élevés, atteignant plus de 40% en certaines années. Les hivers 1975 et 1977 s'avérèrent particulièrement néfastes alors que l'enneigement dépassa le seuil critique de 50 cm durant pratiquement toute la saison. On a estimé que respectivement 200 et 120 cerfs avaient alors péri. La mort par inanition vient au premier rang des cas de mortalité dont on a pu établir la cause. Les faons et les femelles adultes représentent la majorité des 121 cas rapportés au cours de l'étude. Nous croyons que les fortes mortalités observées dépendent des conditions d'hiver extrêmement rigoureuses, même si la nourriture est présente en quantité suffisante, plutôt que d'un état de "surpopulation."

Key Words: White-tailed Deer, *Odocoileus virginianus*; winter, snow, mortality, starvation.

Heavy winter mortality rates for deer have traditionally been associated with "over-population" (Leopold et al. 1943; Robinette et al. 1952; Severinghaus 1956, 1972, 1976; Severinghaus and Free 1963). The traditional attitude of the deer manager under such circumstances has been to allow more liberal hunting seasons to reduce the population. We may ask whether this strategy is still valid on the northern edge of the species' range where severe winters are frequent and may cause mortality in absence of overpopulation. Very few studies have been conducted to document deer mortality under northern conditions, and those are short-term ones (Runge and Wobeser 1975; King 1976). In this paper we have summarized the findings of an 8-yr study on the effects of winter severity on a White-tailed Deer (*Odocoileus virginianus*) population at the northern fringe of its range.

Study Area

The Pohénégamook wintering area is situated 200 km east of Quebec city, in the Lower St. Lawrence region. The most severe winter conditions of Quebec's deer range are reported from this area. Total snowfall is 280 cm and snow thickness or depth reaches 70 cm by mid-March. Duration of the period with more than 50 cm of snow on the ground usually exceeds 80 d.

The topography of the area is gently rolling and the general exposure is in a southwesterly direction. The forest as a whole is characterized by Sugar Maple (*Acer saccharum*) and Yellow Birch (*Betula alleghaniensis*) on the hill tops with Balsam Fir (*Abies balsamea*) and White Spruce (*Picea glauca*) in the valleys (Rowe 1972). Following fire both White Birch (*Betula papyrifera*) and Trembling Aspen (*Populus tremuloides*) gain numerically. Selective cuttings have been the rule for many years in the southern portion of the wintering area while large clear-cuttings were executed in the northern half during the sixties. Since summer 1975, rather heavy mortality occurred in Balsam Fir stands as a result of the recent Spruce Budworm (*Choristoneura fumiferana*) epidemic.

The annual harvest in this area dropped from an average of 70 deer to about 20 bucks after the buck law was instituted in 1974. No important natural predator was present when we initiated the study but the Coyote (*Canis latrans*) appeared in the area in the mid-1970s.

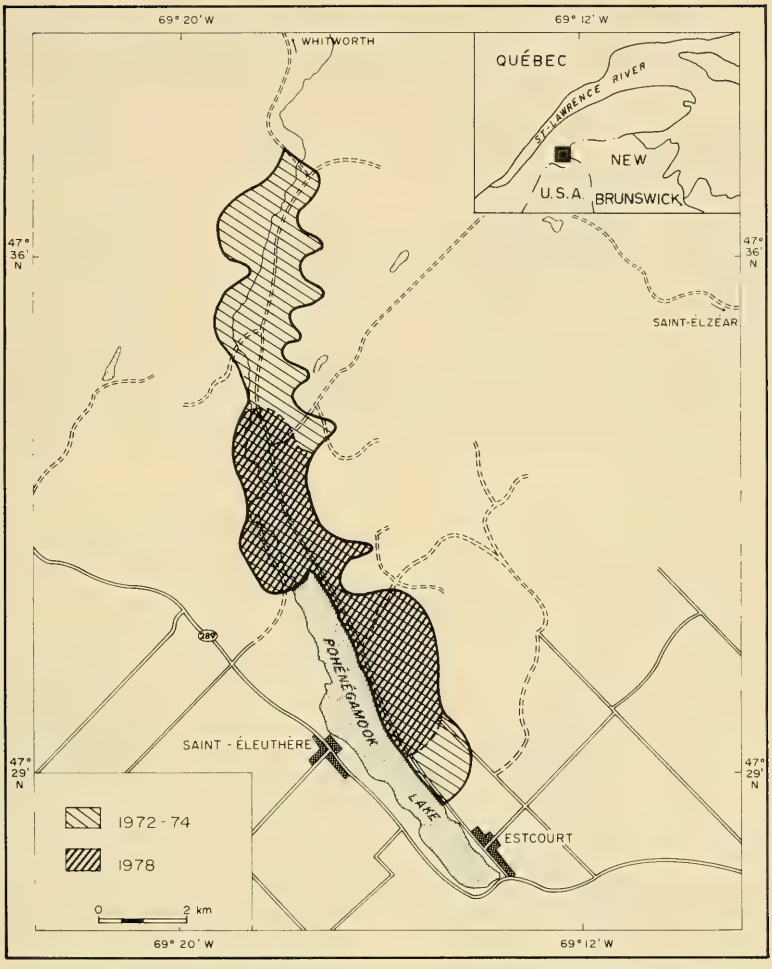

FIGURE 1. Extent of the Pohénégamook wintering area in 1972–1974 and 1978.

Materials and Methods

Aerial surveys were used to map the extent of the wintering area. Each spring or early summer pellet-group counts were taken to estimate the deer population of the previous winter. Sampling plots 2 × 40 m were systematically laid along transects equally spaced and perpendicular to contour intervals. Defecation rate was fixed at 13 pellet-groups per day and number of yarding days was set at 165 (mid-November to end of April).

Snow depth was monitored every winter in a coniferous stand. From 1974 to 1979 systematic dead-body surveys were conducted in the spring, along the same transects used for the pellet-group count, and covered 5–10% of the yard. Dead deer were aged by tooth replacement and wear (Severinghaus 1949) and their physical condition was evaluated by the femur marrow fat content (Cheatum 1949). Deer whose mortality cause was not evident and with less than 25% fat in the bone marrow were classified as dead by starvation.

Results

The wintering area decreased from 30 km² in 1972–1974 to only 11 km² in 1978 (Figure 1). The deer population underwent a 71% decline from 1972 to 1979 passing from 480 to 140 deer (Table 1).

According to snow depth, winters of 1975 and 1977 were the most severe (Figure 2). Under coniferous cover, snow depth exceeded 50 cm for 17 wk or more and reached 70 cm from late January or early February. No supporting crust was present during these two winters except at the end. On the contrary, in 1973 and

TABLE 1—Estimation of deer population and mortality rate in the Pohénégamook wintering area, 1972–1979

Winter	Population from the pellet-group count	No. of dead deer found in the survey	No. of deer estimated to be dead	Population at the beginning of winter[a]	Mortality rate (%)
1972	480 ± 120[b]	No survey			
1973	450 ± 60	No survey			
1974	450 ± 60	5	100	480	21
1975	360 ± 60	14	200	430	47
1976	220 ± 50	0	—	220	—
1977	280 ± 50	7	120	320	38
1978	165 ± 30	11	80	190	42
1979	140 ± 50	4	25	150	17

[a]Population at the beginning of winter = population from the pellet-group count + ⅓ number of deer estimated to be dead. In this equation we assume that deer are dead after 110 d on the average, so that they would not have defecated during the last third of the winter period.
[b]Ninety percent probability confidence limits.

1974 snow depth of 50–60 cm was typical, and a supporting crust facilitated deer movements. The winter of 1976 was also mild as the 50-cm threshold was attained for only 8 wk and snow melt occurred as early as mid-April. However, the winter of 1978 was rather severe because difficult snow conditions were reached at the end of the season when deer are in poor shape. Finally, despite 11 wk with snow depth of 50 cm or more, the winter of 1979 was an easy one because of the presence of a supporting crust from early February.

Deer mortality estimates vary from year to year between 25 and 200, excluding 1976 when no estimate could be obtained as no carcass was found (Table 1). During the winters of 1975, 1977, and 1978, the mortality rate was between 38 and 47% of the population, twice the rate of the winters of 1974 and 1979. Mortality causes were identified for 46 carcasses: 36 cases of starvation, 7 of predation, 2 accidental, and 1 case of poaching. Five of the seven cases of predation were found in 1978, but their identification is doubtful because they were reported by people outside of our study group. The femur marrow of 11 additional deer had a fat content exceeding 25%, but the cause of death could not be identified. Fawns accounted for 44% (n = 94) of all the carcasses and 80% (n = 25) of the starvation deaths. The sex ratio of the adults (1.5 yr and older) was strongly biased toward females, being 24 males per 100 females (n = 44).

Discussion

Severinghaus (1947, 1976) indicated that winter conditions become critical for deer survival when snow depth of 50 cm persists for 50 d or more in the Adirondack region of New York. Deep snow covers low-growing vegetation, increases energy expenditure of deer, and confines them to dense coniferous stands where the food supply is often limited. In 1975 and 1977, this 50-cm critical level was exceeded even in coniferous stands during almost the entire season. Such conditions were associated with mortality rates of 40–50%, twice the rate of winters of 1974 and 1979, two mild years. Deep snow at the end of winter, however, seems to have the same effect because the mortality rate was the same in 1978, when only a short critical period was registered in late March and early April. In April, deer have already exhausted almost all their fat reserves so that any additional energy demand might be too high.

A good habitat can certainly buffer the effects of severe winters; however, the coniferous cover in the Pohénégamook area had been reduced by large clear-cuttings and the recent budworm epidemic. We may expect lower mortality rates for deer facing the same winter conditions in a better habitat.

Most of the deer that died of starvation were fawns. This is normal because fawns have a physical handicap, being smaller, and their metabolic energy needs are proportionally higher. The large preponderance of females in the adult segment is amazing at first and cannot be explained by an excessive removal of males through hunting because the harvest rate on adult males is only about 15%. Females begin the winter in better condition than males because the latter may use a large proportion of their fat reserves during the rut (Siegler 1968). However, it is possible that lactation precludes some females from accumulating fat deposits. Fall foods with a high energetic content such as mast are not available in this area. Furthermore, pregnant females will spend much energy for their fetuses especially at the end of gestation (Verme 1977). This may explain why females are more vulnerable.

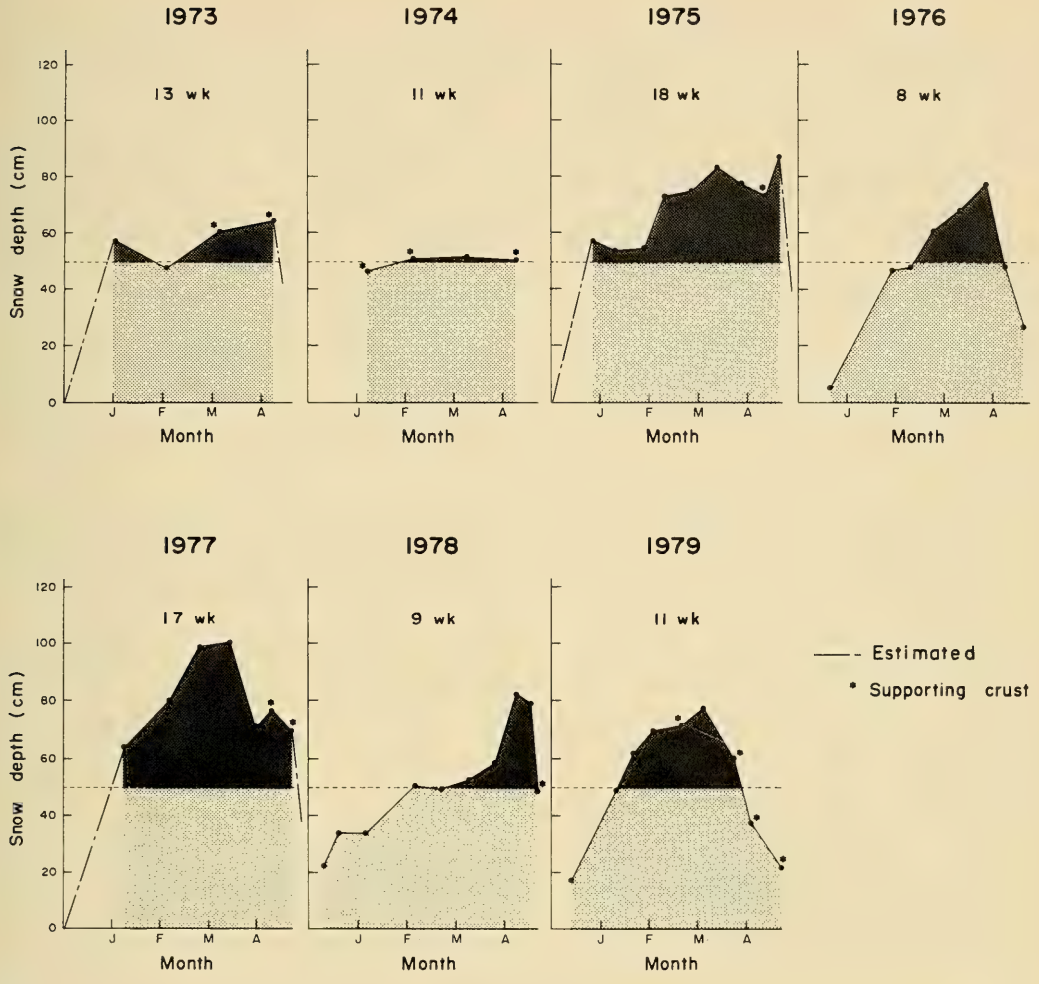

FIGURE 2. Snow depth under coniferous cover and number of weeks with more than 50 cm in the Pohénégamook wintering area, 1973–1979.

In spite of the general belief that overpopulation is responsible for high winter mortality rates, we do not believe that such is the case for the Pohénégamook wintering area. Browse surveys conducted annually since 1972 indicate that only one stem out of three and one twig out of five were browsed by deer in the coniferous forest type which supports the highest deer densities (F. Potvin, unpublished data). This utilization rate is lower than in many other yards in the province and the browse species comprise mostly Mountain Maple (*Acer spicatum*), Beaked Hazelnut (*Corylus cornuta*), and Balsam Fir, typical of our deer range. These twigs were available in winter because only twigs between 50 and 210 cm from the ground were included in the surveys and most of them were above the 70-cm level. Therefore the quantity of food does not appear to be a limiting factor.

Although good quality browse may be abundant in winter, deer will use some of their fat reserves each day, losing 20–30% of their weight during the whole season (Mautz 1974). This is a normal adaptation to compensate for the low digestibility of browse and also to help supply enough energy to face the harsh climatic conditions. A longer winter or difficult snow conditions can exhaust these limited reserves before springtime. Furthermore, a sudden heavy demand caused by rapidly deteriorating climatic conditions (snow storm) or harassment may kill an animal even though its energy reserves are not completely exhausted. This may explain the 11 mortality cases

that had more than 25% of fat in the bone marrow. Mitchell and Staines (1976) made similar observations on Red Deer (*Cervus elaphus*).

Habitat is usually seen as the ultimate limiting factor for deer because this species has no self-regulating mechanism working through behavior or social stress (Klein 1967). But some authors have suggested that winter severity can also act as a regulating mechanism and preclude habitat over-utilization (Klein 1962, 1965; Ransom 1967; Kucera 1976). Potvin et al. (1978) hypothesized that harvest strategies based on the concept of carrying capacity of the range could not be applied at the northern limit of the White-tailed Deer continental range. We believe that under these circumstances deer population dynamics and levels at a given time are related to the general environmental conditions and to the recent history of the herd (exploitation, predation, etc.). When winter conditions are severe for the area, a minimum mortality rate by starvation is to be expected even in the absence of any sign of overpopulation and in a fair to good habitat. Edwards (1956) and Severinghaus (1972, 1976) also suggest this possibility. It appears that, at least in Quebec, occasional severe winters can act almost independently of the deer density and prevent over-utilization of the range by deer.

We then view the regulation of White-tailed Deer populations as an example of the idea suggested by Huffaker and Messenger (1964) according to which the importance of the density-dependent factors decreases as the environmental conditions become more variable and the favorable microhabitats are more scattered. This is probably the case at the limit of the continental deer distribution especially when the habitat cannot buffer these climatic variations. Pohénégamook seems to fit perfectly in this case.

Acknowledgements

We thank C. W. Severinghaus for reviewing the manuscript, M. A. Bédard and G. Boucher for providing unpublished data, and the many persons involved in the surveys.

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Received 25 February 1980
Accepted 30 June 1980

Moose Browse Utilization in Mount McKinley National Park, Alaska

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During winter of 1978–1979, Moose (*Alces alces*) browsing intensities in Mount McKinley National Park averaged 65%. Percentages of available browse consumed were greatest in small, dense, single-species stands of Felt-leaf Willow (*Salix alaxensis*) and less in large, mixed-species stands. Moose populations are below but likely approaching the carrying capacity of the range.

Key Words: Alaska, *Alces alces*, browse, carrying capacity, habitat, Moose, *Salix*.

Mount McKinley National Park supports a Moose (*Alces alces*) population of about 1000 animals in an area of 8000 km^2 (J. Dalle-Molle, National Park Service, Mount McKinley National Park, Alaska, personal communication). There is a higher density of animals in favorable Moose habitat in the park than has been recorded in other regions of interior Alaska with similarly favorable Moose habitat (W. C. Gasaway, Alaska Department of Fish and Game, Fairbanks, Alaska, personal communication). During winter, Moose congregate in tall shrub communities to feed on several species of willow (*Salix* spp.) and other woody vegetation. As part of an extensive Moose browsing study in interior Alaska (Wolff 1978; Wolff and Zasada 1979), we measured browse availability and utilization by Moose in Mount McKinley National Park. It was hypothesized that Moose population density in Mount McKinley National Park would be at or near carrying capacity of the habitat when hunting is totally restricted and fire absent. The last fire recorded in the park occurred in 1924.

To assess this hypothesis, we recorded browsing intensities and the biomass of available browse and estimated carrying capacities in the major wintering areas in the park.

Study Areas and Methods

The major wintering areas for Moose in the park are along Savage, Sanctuary, and Teklanika rivers, Igloo Creek, and near park headquarters. Most of these areas are within 2 km of the park highway. Browsing intensities were recorded in 14 stands at seven sites (Figure 1). One transect was sampled near the park entrance by the railroad tracks (1.8 km from the highway turnoff to the park), one at headquarters (8.3 km), one at Hogan Creek (34.2 km), two at Sanctuary River (34.5 km), one at Sanctuary Campground (35.8 km),one at Teklanika Campground (45.6 km), one at Teklanika River (46.6 km), one at Teklanika Bridge (48.0 km), and two at Igloo Creek (51.0 and 52.0 km). All willows sampled in these stands were Felt-leaf Willow (*Salix alaxensis*); this was a highly preferred willow and an abundant species in the park.

Numbers of browsed and unbrowsed twigs were recorded on 100 willow stems along a 500-m transect in each stand. Two stems closest to the observer (one right and one left) were sampled at 10-m intervals along each 500-m transect. All twigs were less than 4 mm in diameter and between 0.5 and 3.5 m above ground level. Browsing intensity was defined as the proportion of twigs, available to Moose within the sample area, which were browsed.

In three stands along Savage River (11.8 km, 19.8 km, 20.3 km), numbers of browsed and unbrowsed twigs were recorded in 20 plots, 2 × 5 m. All browse species were included in the sampling. The Shafer (1963) twig-count method was used to estimate availability and utilization of browse. Diameters at point of browsing were measured on 30 browsed twigs of each species. Thirty unbrowsed twigs of the same diameter were clipped, dried, and weighed.

A road and aerial census was conducted from 3 through 8 June 1979 to count cows and calves. Additional data on natality, survival, and predation were supplied by the National Park Service and Haber (1977).

Results

Browsing intensities of *S. alaxensis* at the 14 stands are shown in Table 1. The mean browsing intensity for all stands was 65.0% ranging from 35.1% at Teklanika Campground to 86.3% at headquarters, 8.3 km from the park entrance. Browsing intensities corresponded to the distribution and abundance of forage. A mean (± SE) browsing intensity of 75.8 ± 2.91% was recorded in single-species stands and/or stands which

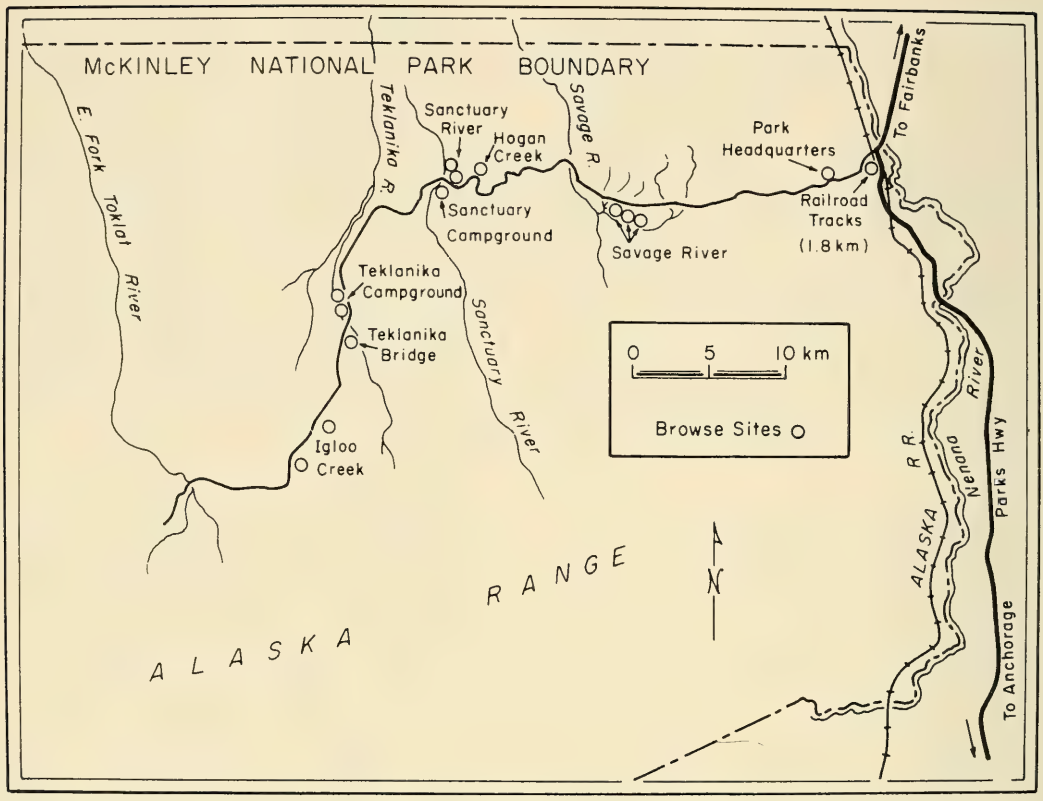

FIGURE 1. Map showing the location of the 14 study sites and the browse sampling sites in Mount McKinley National Park, Alaska.

were dispersed in small dense patches of less than 5 ha (1 ha = 10 000 m^2), such as on river islands, in clearings, or along streams. Browsing intensities were significantly lower ($P < 0.01$, t-test) in mixed-species stands greater than 5 ha in size (52.8 ± 4.08%) or when forage shrubs were widely dispersed. The relative proportions of the stand types in Mount McKinley National Park are not known. There was no correlation between browsing intensities and number of twigs per stem.

Biomass of browse available, carrying capacities, and browse utilization at the three Savage River stands are shown in Table 2. The mean (±SE) diameters at point of browsing were 3.6 ± 0.13 mm for *S. alaxensis*, 2.8 ± 0.09 mm for Littletree Willow (*S. arbusculoides*), and 3.0 ± 0.10 mm for Grayleaf Willow (*S. glauca*). The mean weights per twig were 0.64 ± 0.02 g, 0.55 ± 0.02 g, and 0.60 ± 0.02 g for the three species, respectively. Balsam Poplar (*Populus balsamifera*) is a browse species in other regions of Alaska and was included in the sampling. Balsam Poplar has a mean weight per twig of 1.32 ± 0.07 g for a 4-mm twig (Wolff and Zasada 1979). The amount of browse available ranged from 39.2 to 110.7 kg/ha. This is within the range reported by Wolff and Zasada (1979) for 16 stands in interior Alaska. *Salix alaxensis* made up 90% of the browse available in all stands followed by *S. arbusculoides, S. glauca,* and *P. balsamifera.* Diamondleaf Willow (*S. planifolia*) was also present in the study area but not in our plots. American Green Alder (*Alnus crispa*) was present in most study areas but was infrequently browsed. Preference was shown for *S. alaxensis,* followed by *S. arbusculoides, S. glauca,* and *P. balsamifera.*

At a daily consumption rate of 5 kg dry weight per Moose (Gasaway and Coady 1974), the biomass of browse available in the three stands would support between 5.9 and 16.7 Moose·d^{-1}·ha^{-1} (MD/ha). Moose are usually food-stressed before they consume 100% of the forage available in an area; therefore, actual carrying capacity was adjusted to 75% of total browse available (Wolff and Zasada 1979). The actual

TABLE 1—Numbers of twigs per stem (± SE) and percentage of browsing intensity (± SE) by Moose (*Alces alces*) on *Salix alaxensis* at 14 stands sampled in Mount McKinley National Park, Alaska, during May and June 1979. Number of stems (N) = 100, unless otherwise indicated

Stand	Twigs/stem	Browsing intensity
Single species stands or small dense stands		
Headquarters 1.8 km	4.6 (0.23)	75.7 (3.22)
Headquarters 8.3 km	5.0 (0.25)	86.3 (2.19)
Hogan Creek	6.1 (0.35)	83.7 (3.73)
Sanctuary River I	13.6 (2.22)	75.1 (3.22)
Sanctuary River II	5.3 (0.33)	76.5 (3.15)
Sanctuary Campground	6.0 (0.32)	70.7 (3.12)
Igloo Creek I, 51 km	5.6 (0.26)	63.1 (3.76)
Mean		75.8 (2.91)**
Mixed species stands and/or dispersed stands		
Savage River I (N = 228)	4.3 (0.17)	68.5 (2.61)
Savage River II (N = 224)	11.4 (2.28)	59.1 (2.56)
Savage River III (N = 158)	18.7 (2.70)	50.6 (3.13)
Teklanika Campground	14.9 (2.42)	35.1 (3.88)
Teklanika River, 46.6 km	4.9 (0.25)	44.6 (4.03)
Teklanika Bridge	4.6 (0.26)	53.9 (4.21)
Igloo Creek, 52 km	5.3 (0.26)	57.9 (3.80)
Mean		52.8 (4.08)**

**Percent browsing intensities significantly different ($P < 0.01$, t-test).

utilization of *S. alaxensis* was about 79% of the adjusted carrying capacity. For all browse species utilization was between 64 and 83% of the adjusted carrying capacity.

We counted 23 calves and 27 cows from 3 through 8 June 1979 for a calf:cow ratio of 85:100 (National Park Service aerial census and personal observations). Haber (1977) recorded spring calf:cow ratios ranging from 58:100 to 126:100 from 1966 to 1974. Seven cows we observed had twins for a twinning rate of 26%: the incidence of twinning was between 38 and 55% from 1966 to 1974 (Haber 1977). Fall calf:cow ratios ranged from 12:100 to 38:100 from 1969 to 1973 (Haber 1977) and from 8.2:100 to 18.9:100 from 1974 to 1978 (W. Troyer, National Park Service, Anchorage, Alaska, unpublished report).

Discussion

Earlier Wolff and Zasada (1979) suggested that actual carrying capacity of a habitat is about 75% of total browse available; 25% is either of poor quality, inaccessible, or otherwise too difficult to obtain. They recorded browsing intensities of greater than 75% in small homogenous stands, but larger stands had browsing intensities less than 60%. Similar trends of heavy utilization of small or single-species stands and lighter utilization of large mixed-species stands were noted here. In large mixed-species stands, Moose have

TABLE 2—Production of woody browse and utilization by Moose (*Alces alces*) at the Savage River stands, Mount McKinley National Park, Alaska

Stand	Species	Stems/ha (x ± SE)	Twigs/stem (x ± SE)	Browse available[1] (kg/ha)	Browsing intensities (% ± SE)	Adjusted carrying capacity[2] (M.D./ha[4])	Utilization[3] (M.D./ha[4])
Savage River I	*Salix alaxensis*	11 600 (1700)	4.3 (0.17)	31.9	68.5 (2.61)	4.8	4.4
	S. arbusculoides	2 700 (850)	4.9 (0.33)	7.3	31.7 (5.41)	1.1	0.5
	Total	14 300		39.2	56.8 (3.14)	5.9	4.9
Savage River II	*S. alaxensis*	11 700 (2040)	11.4 (2.28)	85.4	59.1 (2.56)	12.8	10.1
	S. arbusculoides	2 800 (960)	4.0 (0.29)	6.2	55.0 (5.05)	0.9	0.7
	S. glauca	300 (250)	5.8 (1.31)	1.0	16.0 (6.79)	0.2	0
	Total	14 800		92.6	58.0 (2.45)	13.9	10.8
Savage River III	*S. alaxensis*	8 500 (1500)	18.7 (2.70)	101.7	50.6 (3.13)	15.3	10.3
	S. arbusculoides	2 800 (960)	4.0 (0.29)	6.2	34.6 (7.86)	0.9	0.4
	S. glauca	300 (160)	5.7 (0.58)	1.0	23.0 (8.05)	0.2	0
	Populus balsamifera	150 (80)	9.0 (1.52)	1.8	0	0.3	0
	Total	11 750		110.7	48.1 (2.94)	16.7	10.7

[1]*Salix alaxensis* 0.64 g/twig, *S. arbusculoides* 0.55 g/twig, *S. glauca* 0.60 g/twig, *P. balsamifera* 1.32 g/twig.

[2]Adjusted carrying capacity: $\frac{75\% \text{ of browse available}}{5 \text{ kg} \cdot \text{Moose}^{-1} \cdot \text{d}^{-1}}$ (Wolff and Zasada 1979).

[3]Utilization: $\frac{\text{Browsing intensity} \times \text{total browse available}}{5 \text{ kg} \cdot \text{Moose}^{-1} \cdot \text{d}^{-1}}$ (Gasaway and Coady 1974).

[4]M.D./ha: Moose days per hectare.

a greater number of species and individual plants from which to select good quality forage (Oldemeyer et al. 1977) than they do in smaller and more dense single-species stands. In small, patchily distributed stands it is probably easier to consume large quantities of forage before moving to another patch.

The relatively high browsing intensities recorded suggest that the population is approaching or at the carrying capacity as determined by available food. Subjective observations made during this study suggest browsing intensities were also high in previous years, but relatively high twinning and natality rates in 1979 indicate the population might still be below the actual carrying capacity. If this is the case, the Moose population is currently being controlled by some means other than low forage availability. The twinning rate was lower in 1979 than in previous years, however, and this suggests that forage quality or quantity may be becoming a limiting factor in Moose numbers. Small sample sizes prevent drawing any firm conclusions.

The drop in calf:cow ratios recorded from spring to fall suggest high summer mortality, likely the result of predation by Gray Wolves (*Canis lupus*) or, to a lesser extent, Grizzly Bears (*Ursus arctos*) (Haber 1977; Gasaway et al. 1977; S. Buskirk, National Park Service, Mount McKinley National Park, Alaska; and W. Ballard, Alaska Department of Fish and Game, Glenn Allen, Alaska, unpublished report). Even if predation were reduced, the Moose population might increase by only 10–15% before reaching the current carrying capacity of the habitat.

Most of the tall willow shrub communities in upland sites in the park are in a climax state with low current annual growth. The seral communities along the major river systems are self-perpetuating with yearly alluvial deposits providing a substrate for primary succession of willow communities. An increase in seral habitat resulting from fire in uplands or continued alluvial deposition along rivers would improve Moose habitat in Mount McKinley National Park. Species composition and size of stands should be taken into consideration when evaluating and managing Moose habitat.

Acknowledgments

We thank William C. Gasaway, and two anonymous reviewers for helpful comments on this manuscript. J. Dalle-Molle provided unpublished data and logistic support. This study was financed by cooperative aid agreement 48-PNW-78 between the University of California, Berkeley, and the Institute of Northern Forestry, Pacific Northwest Forest and Range Experiment Station, Fairbanks, Alaska.

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Received 7 January 1980
Accepted 23 May 1980

The Sedge *Carex loliacea* in Eastern North America

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Reznicek, A. A., and P. W. Ball. 1981. The Sedge *Carex loliacea* in eastern North America. Canadian Field-Naturalist 95(1): 89–92.

Carex loliacea, a circumboreal sedge found mostly in northwestern North America, has been known since 1954 from the northern boreal forest of Ontario. Recent collections have considerably extended its range eastward and southward and it is now known from within the area covered in Gray's Manual. A key is provided separating *C. loliacea* from other similar species in eastern North America, and complete citations of all known collections east of Manitoba are given.

Key Words: *Carex loliacea*, flora, Ontario, geographical distribution, records.

Carex loliacea (section Heleonastes) is an essentially circumboreal species that is widespread in northern Asia, northern Europe, and northwestern North America (Hultén 1968). Recently it has been reported from a few scattered localities in the northern boreal forest of Ontario (Dutilly et al. 1954; Baldwin 1958; Moir 1958). These published records are outside the area covered by the northeastern North American floras (Fernald 1950; Gleason 1952; Gleason and Cronquist 1963), and the species does not extend sufficiently north to be included in eastern arctic floras (e.g. Porsild 1964). Recent collections (cited below) have greatly extended its known range both eastward and southward so that it is now known from within the area covered by Fernald (1950) and closely approaches the area of Gleason (1952) and Gleason and Cronquist (1963).

In this paper we report the distribution of *C. loliacea* in Ontario and discuss ways in which it can be distinguished from similar species. We hope that botanists will become more familiar with the species so its distribution and ecology in eastern North America will become more fully known.

Description of *Carex loliacea*

Carex loliacea has a loosely cespitose habit with an infructescence of few separated spikes bearing a few narrowly elliptical spreading or reflexed perigynia. In these characters it closely resembles a number of widespread and common eastern North American species of *Carex* subgenus *Vignea*, particularly *C. interior* of section Stellulatae, *C. sylvicola* (*C. rosea* auct.) of section Bracteosae, and *C. disperma* of section Heleonastes, and to a lesser extent several other members of sections Heleonastes and Stellulatae. This convergence in appearance is a remarkable feature and has several other parallels in *Carex*, for example, in the west, there is great similarity between *C. illota* of section Ovales, *C. hoodii* of section Bracteosae, *C. vernacula* of section Foetidae, and *C. jonesii* of section Vulpinea. *Carex loliacea* can be most readily recognized by the complete absence of a beak on the perigynium, although in a number of other similar species the beak may be extremely short (0.2 mm long). In this regard *C. disperma* is the species most likely to be confused with *C. loliacea* because it occurs in similar habitats, may have virtually no beak on the perigynium, and has only one or two staminate flowers in the terminal spike which can be easily overlooked. Although the position of the staminate flowers is the only certain means of distinguishing these species, there are several other features which may be useful. For example, the perigynia of *C. disperma* are either erect or spreading at an angle of less than 90° to the main axis, tend to taper rather abruptly at the apex, and often have nine or fewer rather thin nerves on each surface. The perigynia of *C. loliacea* often spread at an angle of 90° or greater to the main axis, taper very gradually from the middle to the apex, and often have nine or more rather stout nerves on each surface. Two representative infructescences of *C. loliacea* are illustrated in Figure 1.

Identification Key

We have provided the following short key to facilitate identification. This key includes all northeastern North American species of *Carex* subgenus *Vignea* that are cespitose and which have infructescences composed of several simple spikes. Species other than *C. loliacea* are not keyed in detail.

1 Terminal spike with staminate flowers at apex or entirely staminate.
..... Section Bracteosae, *Carex disperma, C. sterilis*

1 Terminal spike with staminate flowers at base or entirely pistillate.

FIGURE 1. Two representative infructescences of *Carex loliacea*.

2 Perigynia lanceolate to broadly ovate, widest well below middle; spongy layer at base of perigynium thick, occupying basal ⅓ to ½ of perigynium body, usually marked by an externally differentiated zone (except in *C. arcta*) ..... Section Stellulatae, *Carex arcta*

2 Perigynia narrowly to broadly elliptic, widest near middle; spongy layer at base of perigynium thin or absent, not marked by an externally differentiated zone.

3 Lower two spikes of infructescence overlapping, the apex of the lowest reaching to or beyond the base of the next spike. ..... *Carex glareosa, C. lachenalii, C. heleonastes, C. tenuiflora, C. amblyorhyncha, C. mackenzei*

3 Lower two spikes of infructescence separate, the apex of the lowest not reaching to the base of the next spike.

4 Perigynia tapering uniformly to the apex, not contracted to a beak ..... *Carex loliacea*

4 Perigynia abruptly contracted to a short but definite beak 0.2–0.9 mm long ..... *Carex canescens, C. brunnescens, C. tripserma, C. mackenzei*

Distribution and Ecology of *Carex loliacea*

The known distribution of *Carex loliacea* east of Manitoba now extends to within 130 km of the Quebec boundary (Figure 2). It is likely that searches will disclose this species in Quebec. In Ontario, the species is rare in the northern boreal forest and occurs disjunctly near the north shore of Lake Superior (Figure 3), paralleling a number of other northern species (Soper and Maycock 1963). This species should be looked for in the Lake Superior area of Minnesota and Michigan as well.

Virtually no information is available about the ecology of the species in eastern Canada. It evidently grows in *Sphagnum* bogs shaded by conifers and in rich, wet sites that are mossy but often with little or no *Sphagnum*. Most of the collections are along river banks or associated with small streamlets. At the Moose River site (TRTE 5348) the species occurred

FIGURE 2. Distribution of *Carex loliacea* in North America.

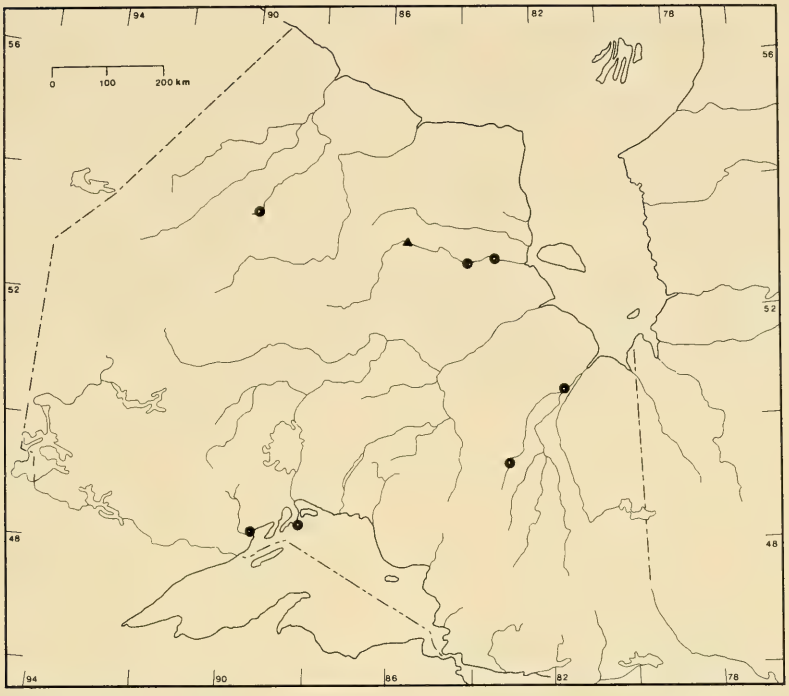

FIGURE 3. Distribution of *Carex loliacea* in Ontario. ● Specimens examined. ▲ Literature records.

with *Carex media* and other fine-leaved sedges on the sides of small, mossy hummocks in a network of streamlets through *Picea glauca* (White Spruce) –*Thuja occidentalis* (White Cedar) woods just above the bank of the Moose River.

Ontario Records of *C. loliacea*

Kenora District

Fawn River between Big Trout Lake and Otter River, 8 July 1952, Moir 357. Deep Sphagnum bog (CAN 259793).

Attawapiskat River 53°08′N, 83°18′W. 17 July 1957. Porsild et al. 20253. Dry river bank (CAN 787751).*

Attawapiskat River, 60 miles (100 km) upstream from town. 7 July 1977. Riley 6699. Closed spruce forest by cool seepage streamlet (TRT 202024) (sub *C. brunnescens*).

Albany R. au rapide Frenchman. 51°22′N, 87°48′W. 22 August 1952. Dutilly, Lepage & Duman 30574. Bois de conifères (n.v.).

*A number of other specimens from this locality collected in the same year (e.g., Porsild et al. 20096, 20205) were distributed as *C. loliacea*. These specimens are *C. disperma*.

Thunder Bay District

Port Arthur, east of Hodder Avenue. 2 July 1950. Garton 1156. In muskeg under alders. (DAO 172285).

Brodeur Island, Lake Superior. Bay at north end of island, 48°33′N, 88°18′W. 8 July 1973. Soper & Given 13151. In *Sphagnum* under Balsam–Spruce. (CAN 367847) (sub *C. interior*).

Algoma District

Kapuskasing; 26 miles (42 km) southwest in Shanly Tp., on Kapuskasing River. 30 June 1953. Baldwin 4963. Road through old black spruce forest. (CAN 225843).

Cochrane District

Canfield Tp. Grey Goose Island; 5½ miles (9 km) south west of Moose River railway crossing. 50°46′N, 81°24′W. 15 July 1974. Reznicek & Carlton. Wet mesic Black Spruce – White Cedar forest at river's edge. Infrequent on hummocks associated with runnels of water (TRTE 5348).

Acknowledgements

Our thanks to the curators of the herbaria cited for making their material available to us and to G. W. Argus and D. J. White for permission to publish the maps. This work was partially financed by Natural Sciences and Engineering Research Council of Canada grant A6494.

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Received 6 March 1980
Accepted 17 June 1980

Notes

First Records of the Tundra Shrew (*Sorex tundrensis*) in British Columbia

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Nagorsen, David W., and Donald M. Jones. 1981. First records of the Tundra Shrew (*Sorex tundrensis*) in British Columbia. Canadian Field-Naturalist 95(1): 93–94.

Five Tundra Shrews (*Sorex tundrensis*) were collected near Haines Road in northwestern British Columbia. These are the first records of the Tundra Shrew outside the boundaries of the Beringian Refugium, and they extend the range of this shrew about 500 km south of its known limits.

Key Words: Tundra Shrew, *Sorex tundrensis*; new records, British Columbia, Beringian Refugium.

The Arctic Shrew (*Sorex arcticus*)[1] and the Tundra Shrew (*Sorex tundrensis*)[1] are boreal and tundra forms of the *Sorex arcticus* group described by Jackson (1928). The two taxa are allopatric in distribution (Figure 1). The Arctic Shrew inhabits the southern Yukon, southwestern Northwest Territories, central and eastern Canada, and north central United States. The Tundra Shrew is restricted to Alaska, northern Yukon, and Northwest Territories. As there are few records from the Yukon and Northwest Territories, the limits of the geographic ranges of these two shrews are poorly known.

During field studies in 1978 and 1979, one of us (D. Jones) collected five specimens of the *S. arcticus* group near Haines Road, Cassiar District, British Columbia. These specimens are deposited in the collections of the Department of Mammalogy, Royal Ontario Museum (ROM Nos. 82833, 82834, 83471, 83497, 83498). Based on cranial measurements from the five specimens (Table 1) and pelage of a skin prepared from 83471, we identified these shrews as Tundra Shrews. These represent the first records for this shrew in British Columbia.

Five Tundra Shrews were trapped at three sites. In August 1978 two specimens were taken in an alpine willow community (59°41′N, 136°34′W) at an elevation of 1037 m adjacent to a stream. The community was dominated by willows (*Salix* sp.), about 1.5 m tall, and various species of bryophytes and Gramineae. Other plants included horsetails (*Equisetum* sp.), sedges (*Carex* sp.), yarrow (*Achillea* sp.), Burnet (*Sanquisorba stipulata*), Larkspur (*Delphinium glaucum*), Wormwood (*Artemisia arctica*), Indian Paint-

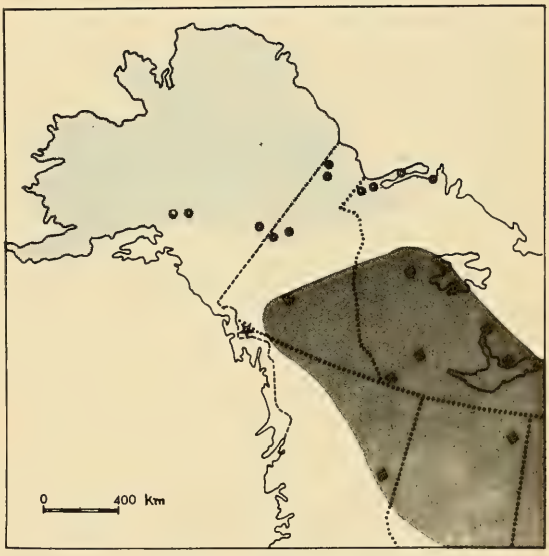

FIGURE 1. Distributions of the Tundra Shrew (light gray) and Arctic Shrew (darker gray) in northwestern North America (modified from Hall and Kelson 1959 and Youngman 1975). Diamonds are peripheral records for the Arctic Shrew, dots are peripheral records for the Tundra Shrew, and the star indicates the Tundra Shrew records from northwestern British Columbia.

[1]Although the Tundra Shrew has a smaller skull, shorter tail, and lighter ventral pelage than the Arctic Shrew, the taxonomy has been problematic and the Tundra Shrew has been regarded as a subspecies of the Arctic Shrew, *Sorex arcticus tundrensis* (Bee and Hall 1956; Banfield 1974) and as a distinct species, *Sorex tundrensis* (Jackson 1928; Youngman 1975; C. G. van Zyll de Jong, personal communication).

TABLE 1—Comparison of means (ranges) in millimetres of selected cranial measurements of the five Tundra Shrews from British Columbia with Tundra Shrews from Alaska and Arctic Shrews from the Northwest Territories and Yukon.

	Sample size	Condylobasal length	Cranial breadth	Palatal length	Maxillary toothrow length
Tundra Shrew					
Haines Road, British Columbia	5	18.1 (17.8–18.3)	8.9 (8.7–9.0)	7.3 (7.1–7.4)	6.3 (6.2–6.4)
Northeastern Alaska*	13	17.9 (17.2–18.5)	9.1 (8.7–9.4)	7.3 (7.0–7.5)	6.6 (6.4–6.8)
Arctic Shrew					
Fort Norman, Northwest Territories*	4	18.9 (18.7–19.2)	9.4 (9.1–9.5)	7.8 (7.6–8.1)	7.0 (7.0–7.0)
Yukon Crossing, Yukon*	1	20.3	10.4	8.6	7.8

*Measurements denoted by an asterisk are from Youngman (1975).

brush (*Castilleja unalaschcensis*), Bluebell (*Mertensia paniculata*), and Northern Grass-of Parnassus (*Parnassia palustris*).

Two specimens were collected in August 1979 in a subalpine willow community (58° 48′N, 136° 37′W) at 885 m. This community also bordered a stream, and vegetation was similar to that of the alpine willow community described above. Another Tundra Shrew specimen was trapped in June 1979 in a subalpine grass community (59° 49′N, 136° 36′W) at 885 m. This habitat was dominated by willows, Wormwood, sedges, Dwarf Birch (*Betula glandulosa*), and various species of Gramineae and Compositae. Small mammals trapped at Tundra Shrew sites included the Dusky Shrew (*Sorex monticolus*), Long-tailed Vole (*Microtus longicaudus*), Tundra Vole (*Microtus oeconomus*), Meadow Vole (*Microtus pennsylvanicus*), Heather Vole (*Phenacomys intermedius*), and Deer Mouse (*Peromyscus maniculatus*).

There are no records of the Tundra Shrew from southeastern Alaska or southern Yukon (Hall and Kelson 1959; Youngman 1975), and our specimens extend the range of this species about 500 km south of its known limits (Figure 1). Other populations of Tundra Shrews may occur in alpine habitats in the Coast Mountains of southern Alaska and northwestern British Columbia. Rand (1954), Hoffman and Peterson (1967), and Youngman (1975) hypothesized that the Tundra Shrew was isolated in an unglaciated region of Alaska and the Yukon (Beringian Refugium) during the Wisconsin glaciation, and Youngman (1975) noted that the present distribution of this species is completely within the boundaries of Beringia. Our records from northwestern British Columbia, however, are 450–550 km south of the limits of the Beringian Refugium (as mapped by Prest et al. 1968). Presumably this population in British Columbia resulted from postglacial dispersion.

Acknowledgments

We especially thank Stan van Zyll de Jong, National Museum of Natural Sciences, Ottawa, for verifying our identifications of the Tundra Shrews and for providing us with his unpublished morphometric data on the *Sorex arcticus–tundrensis* group. Fieldwork was part of an M.Sc. research by Donald Jones and was supported by research grants from the University of Waterloo and from NSERC to John Theberge. Adriana Jones is acknowledged for her capable field assistance. We thank J. R. Tamsitt and R. L. Peterson for critically reviewing the manuscript.

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Received 26 May 1980
Accepted 16 July 1980

Great Blue Heron (*Ardea herodias*) Colony in the Peace–Athabasca Delta, Alberta

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Kristensen, John. 1981. Great Blue Heron (*Ardea herodias*) colony in the Peace–Athabasca Delta, Alberta. Canadian Field-Naturalist 95(1): 95–96.

The northernmost colony of Great Blue Herons (*Ardea herodias*) was recorded in the Peace–Athabasca Delta, Alberta, in 1977.

Key Words: Great Blue Heron, *Ardea herodias*, bird colony, Peace–Athabasca Delta, Wood Buffalo National Park, Alberta.

On 24 August 1977, while conducting research on Goldeye (*Hiodon alosoides*), I found an active Great Blue Heron (*Ardea herodias*) colony in the Wood Buffalo National Park section of the Peace–Athabasca Delta in northeastern Alberta, following information given me by E. Courtorielle, a local trapper. This represents the northernmost known breeding locality of the species.

The heronry was situated on a small point of land on the left bank of the Birch River (58° 27'N, 112° 17'W; Figure 1) about 100 m from the river. Dominant tree cover consisted of Balsam Poplar (*Populus balsamifera*) and the understory was dominated by Red Osier Dogwood (*Cornus stolonifera*), Low-bush Cranberry (*Viburnum edule*), and River Alder (*Alnus tenuifolia*). Ground cover consisted primarily of horsetails (*Equisetum* spp.) and grasses.

The heronry consisted of 12 nests, all located 12–18 m above ground in living Balsam Poplar trees. Four trees contained two nests each; nests in the same tree were as little as 4 m apart. The other nests were constructed one to a tree. All of the nests were located within a circular area of about 30 m radius. One fallen nest was slightly less than 1 m in diameter, constructed almost entirely of Balsam Poplar branches, and lined with Balsam Poplar leaves. A dead Great

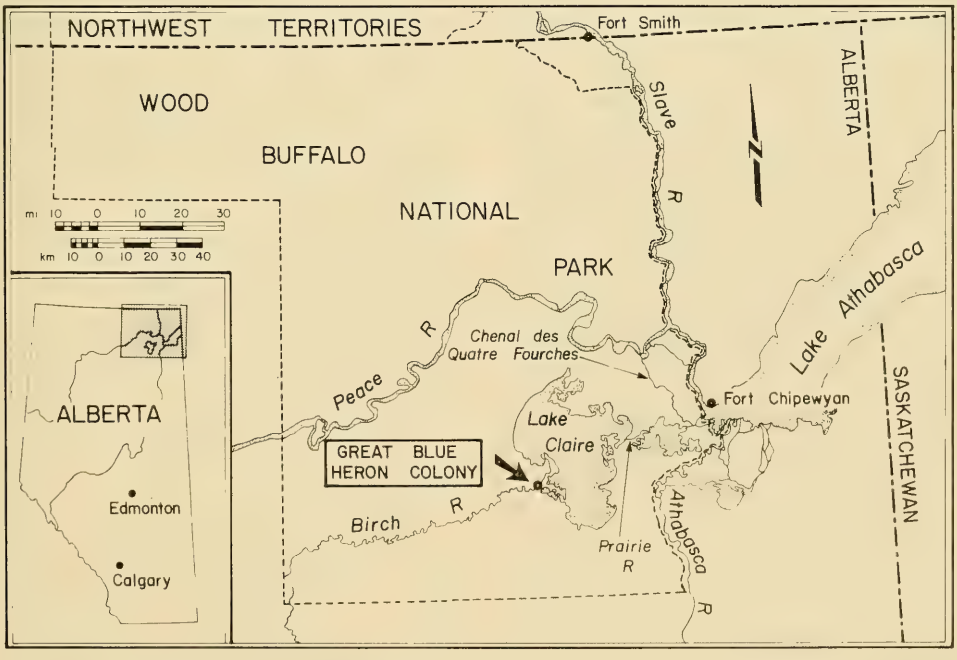

FIGURE 1. Location of the Great Blue Heron colony along the Birch River.

Blue Heron nestling was found on the ground beneath another nest. Egg shell fragments were present beneath several nests, as were abundant remains (scales, caudal fins, vertebrae, and skull fragments) of Goldeye, Northern Pike (*Esox lucius*), and Walleye (*Stizostedion vitreum*).

This colony, as far as is known (Godfrey 1966; W. E. Godfrey, National Museum of Natural Sciences, personal communication), is the northernmost breeding locality of Great Blue Herons in Canada. Jung (1930) was told (presumably by residents of Fort Chipewyan) that Great Blue Herons nested along the south shore of Lake Athabasca, but no heronry was found at that time. The previous northernmost definite record of a heronry in Alberta was at Pelican Lake at approximately 55° 50′N (Vermeer 1969). Most Great Blue Heron colonies in Alberta have been located in the southern half of the province (Vermeer 1969; Salt and Salt 1976). Colonies in other provinces were also south of the colony described in this note (Vermeer 1973; Mark 1976; Gray et al. 1980).

Residents of Fort Chipewyan have only recently observed Great Blue Herons regularly in the Peace–Athabasca Delta (personal communications with local trappers and fishermen). The Great Blue Heron was listed as an "accidental visitant" in Wood Buffalo National Park by J. D. Soper (1935. Mammals and birds of Wood Buffalo Park, northern Alberta and District of Mackenzie. Canadian Wildlife Service unpublished report. 365 pp.) and as a "rare vagrant" in the Peace–Athabasca Delta by Höhn (1973). A single bird was observed along the Chenal des Quatre Fourches by Jung (1930). Great Blue Herons have been observed in the Birch River area from 1975 to 1979, and as far north as the Salt River (59° 52′N, 112° 03′W) (E. Kuyt, Canadian Wildlife Service, personal communication). I observed numerous single Great Blue Herons along the Chenal des Quatre Fourches during 1975 and 1980, and several single birds along the Prairie River in 1975 and 1976.

On the basis of the suggestion by Vermeer (1969) that herons' excrement contributes to the death of trees that they nest in, I concluded that the Birch River heronry, composed of nests in live trees, is probably relatively recent. Although the Balsam Poplar trees and understory were covered with excrement, they appeared to be healthy and there was no evidence of nettles, etc., plants typically found where the soil has been enriched with excrement.

Great Blue Herons and their nesting colonies are conspicuous and vulnerable to disturbance by humans. Industrial and lakeshore residential expansion may have diminished both the number and size of Great Blue Heron colonies in Alberta (Salt and Salt 1976), and Vermeer (1969) indicated that some Great Blue Herons in Alberta have moved to new locations as a result of human disturbance. The northern nesting of Great Blue Herons in Alberta, shown by this record may be a result of increasing human development and disturbance in more settled areas, coupled with ideal feeding habitat for Great Blue Herons in the Peace-Athabasca Delta. It is also possible that the apparent recent northward expansion of Great Blue Heron colonies in Alberta and other provinces is an artifact of increasing northern field work.

Thanks are extended to A. Courtorielle for assisting me in locating the heronry; to W. E. Godfrey, E. Kuyt, W. J. Richardson, R. E. Salter, S. G. Sealy, and C. E. Tull for reviewing an earlier draft of this note; and to K. Bruce for preparing the figure.

The heronry was located while the author was under contract with LGL Limited to Fisheries and Environment Canada.

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Received 13 March 1980
Accepted 15 August 1980

An Unusually Small American Eel (*Anguilla rostrata*) from the Lake Superior Drainage[1]

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Cochran, Philip A. 1981. An unusually small American Eel (*Anguilla rostrata*) from the Lake Superior drainage. Canadian Field-Naturalist 95(1): 97–98.

An unusually small specimen (total length 157 mm) of the American Eel (*Anguilla rostrata*) was collected from the Lake Superior drainage. At least some eels in Lake Superior must migrate directly into the lake at a small size. The specimen in question is much smaller than the size previously inferred for eels migrating into the Great Lakes at Lake Ontario.

Key Words: *Anguilla rostrata*, American Eel; Lake Superior, Great Lakes, Anguillidae, geographic distribution, body size, migrations.

A specimen of the American Eel, *Anguilla rostrata*, was collected on 11 February 1978 from the Blackhoof River, a tributary of the Nemadji River in the Lake Superior basin (Carlton County, Minnesota, 46°33′N, 92°28′W). The stream at the site of capture was ~0.5 m deep and 5–6 m wide, with open water at the center and shelf ice along the banks. Total length of the specimen was 157 mm. It was given to James C. Underhill to be deposited in the University of Minnesota collection.

American Eels have been present in the Upper Great Lakes in small numbers for some time (Hubbs and Lagler 1964), including Lake Superior (Moore and Braem 1965; Eddy and Underhill 1974). It is generally presumed that they have gained access to the Upper Great Lakes through the St. Lawrence Seaway (Eddy and Underhill 1974) or the Welland Canal (Eales 1968; Scott and Crossman 1973). The possibility of eels also gaining access to the Great Lakes from the Mississippi drainage via the Chicago Drainage Canal has apparently been overlooked by recent authors, although Hubbs and Lagler (1964) stated that several fish species may have used it to enter Lake Michigan. As early as 1815, Clinton (see Webster 1980) discounted the possibility of young eels migrating upstream against the rapid currents of the Mississippi and Illinois rivers to take advantage of the then seasonal connection between the Lake Michigan and Mississippi drainages. Nevertheless, eels penetrate the upper Mississippi River and its tributaries as far north as Minnesota (Eddy and Underhill 1974), and specimens have been collected from the Illinois River as recently as 1974 (Sparks and Starrett 1975). Sparks and Starrett (1975) commented on an improvement of water quality in the upper Illinois River and Chicago Canal resulting from aeration and improved waste treatment. This would conceivably facilitate fish movements.

The significance of the Blackhoof River record is that it apparently represents by far the smallest American Eel yet taken in the Lake Superior basin. The next smallest specimens that could be located on record measured 373 mm (J. C. Underhill, personal communication) and 406 mm (Moore and Braem 1965). The Blackhoof specimen is evidence that at least some American Eels migrate directly into Lake Superior and reach the western limit of their Great Lakes distribution at a small size, much smaller than the 200- to 300-mm length inferred by Hurley (1972) for eels entering Lake Ontario. It might previously have been supposed that the few large eels captured in Lake Superior had merely wandered into the lake after attaining their size elsewhere, because American Eels are capable of long movements (e.g., Vladykov 1956) and have been known to make movements apparently not associated with sexual maturity or reproduction (Smith and Saunders 1955).

Capture of the Blackhoof specimen was fortuitous. It was collected with electrofishing gear during the marking run of a mark-and-recapture population estimate for Brown Trout (*Salmo trutta*) and Rainbow Trout (*Salmo gairdneri*). In the water it was mistaken for a larval lamprey, which were being stunned in some numbers and which it resembled in general form and coloration. It was set aside for later scrutiny, the only "lamprey" so collected. After its true identity was revealed, however, close attention was paid to the lampreys stunned during the recapture run over the same stretch of stream the next day, but no additional eels were observed. Fisheries personnel working along Lake Superior tributaries should nevertheless be aware of the possibility of securing additional specimens of small American Eels which

[1]Paper Number 11123, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota 55108.

might easily be overlooked because of a superficial resemblance to lampreys.

George C. Becker (Department of Biology, University of Wisconsin—Stevens Point), E. J. Crossman (Royal Ontario Museum), and James C. Underhill (Department of Zoology, University of Minnesota, Minneapolis) kindly made available their records of American Eels from Lake Superior. James C. Underhill and Thomas F. Waters read earlier drafts of the manuscript.

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Received 5 March 1980
Accepted 27 May 1980

Panicled Knapweed (*Centaurea paniculata:* Compositae) New to Eastern Canada

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Brunton, Daniel F., and Paul D. Pratt. 1981. Panicled Knapweed (*Centaurea paniculata:* Compositae) new to eastern Canada. Canadian Field-Naturalist 95(1): 98–99.

The discovery of a small station of Panicled Knapweed, *Centaurea paniculata*, in Essex County, Ontario, constitutes the first locality for this species in eastern Canada and the second for North America. This introduced species is very rare in Ontario.

Key Words: *Centaurea paniculata*, Compositae, Ontario, rare flora, new records, eastern Canada.

The Panicled Knapweed (*Centaurea paniculata*) is a rare introduction in Canada and was previously known only from Vancouver Island, British Columbia, before the recent discovery of a station in Essex County, Ontario. It is a native of Europe, ranging across the Mediterranean region from the Iberian Peninsula to Italy and Switzerland. Although first collected in Victoria in 1893 by John Macoun and noted occasionally thereafter on southern Vancouver Island, it has not become well established nor has it been found elsewhere in British Columbia (Moore and Frankton 1974). It is not listed in Montgomery (1957), Boivin (1967), Scoggan (1979), Gleason (1952), Hitchcock et al. (1955), or Fernald (1950), indicating that this species is largely unknown as an element of the North American flora and is apparently unknown in the United States. A specimen search in the DAO, CAN, and MICH herbaria revealed no additional records, nor did an examination of the large number of Essex County specimens in the personal herbarium of W. Botham.

The *C. paniculata* – *C. maculosa* group of *Centaurea* is complex and its species have been combined under various specific and subspecific rankings. The Essex County material keys out to *C. paniculata* ssp. *esterellensis* (Burnat) Dostál (Dostál 1976), a taxon of southeastern France. The validity and relationships of this taxon are not clear.

The Ontario station is located on disturbed ground near a railway spur line. No additional plants were noted in the area; however, a thorough search was not conducted. Its means of introduction is unknown, although the railway line is an obvious possibility. It seems quite unlikely that these plants originated from the Victoria population, given the species' inability to become well established even there. It is more likely that the Essex County station represents an independent introduction from Europe. The species is also known in Great Britain (Fitter and Fitter 1974) where it was probably introduced. It seems that the Ontario station may have originated from any of a number of areas.

The label data for the new collection are as follows: 1.75 km NE of Amherstberg (sic), Anderdon Twp., Essex Co., Ontario. 42° 07′N, 78° 05′W. On overgrown road across bare limestone in old quarry, growing in open with *Melilotus* spp. 2 September 1979. *D. F. Brunton & P. D. Pratt 1933* (DAO).

On the basis of the three or four plants noted at the Essex County station, *C. paniculata* would seem to be very rare in eastern Canada.

We greatly appreciate the assistance of C. Frankton for his critical review of the determination, his comments on *Centaurea* in general, and for his review of an earlier draft of the manuscript. Our thanks also go to the curators of DAO and CAN for their assistance. A. A. Reznicek was kind enough to examine the University of Michigan collection for us and his assistance is also appreciated.

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Received 15 April 1980
Accepted 21 July 1980

Ruby-crowned Kinglets (*Regulus calendula*) Feeding a Brown-headed Cowbird (*Molothrus ater*)

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Boxall, Peter C. 1981. Ruby-crowned Kinglets (*Regulus calendula*) feeding a Brown-headed Cowbird (*Molothrus ater*). Canadian Field-Naturalist 95(1): 99–100.

A pair of Ruby-crowned Kinglets (*Regulus calendula*) were observed feeding a fledged Brown-headed Cowbird (*Molothrus ater*). This is the third report of successful brood parasitism upon Ruby-crowned Kinglets, despite a number of observations of cowbird eggs in kinglet clutches.

Key Words: *Regulus calendula, Molothrus ater*, brood parasitism, British Columbia.

On 1 August 1979, I observed a young Brown-headed Cowbird (*Molothrus ater*) being fed by a pair of Ruby-crowned Kinglets (*Regulus calendula*) at the south end of Bridge Lake (51° 29′N, 120° 42′W), about 80 km N of Kamloops, British Columbia. I was attracted to the scene by the loud begging calls of the cowbird. Although cowbirds are usually noisy and aggressive towards their foster parents (Lavers 1974), this particular bird seemed more vocal than cowbirds I have seen attended by Yellow Warblers (*Dendroica petechia*) or Tennessee Warblers (*Vermivora peregrina*). I continued to watch the trio to see whether the

much smaller kinglets were having problems supplying enough food to the cowbird. From 16:50 to 17:30 (PDT), I observed four instances of both kinglets feeding the cowbird virtually simultaneously, and 14 feedings by a single kinglet. The cowbird begged persistently and chased its fosterers for 1–2 m several times. I returned to the area a number of times over the next 3 d, and I found one kinglet each time but did not find or hear a begging fledgling.

This observation is the third report of successful parasitism by the Brown-headed Cowbird upon the Ruby-crowned Kinglet. The latter were initially considered very rare victims of cowbirds owing to the disparity in size between the two species (Friedmann 1929). Friedmann et al. (1977), however, reported 14 cases of cowbird parasitism on the Ruby-crowned Kinglet, and suggested that it may be a regular if not a favorite host. Seven records involved the western race *Regulus calendula cineraceus*; six from California and one from British Columbia (Grant 1965). Apparently, 12 of the 14 cases involved cowbird eggs seen in kinglet nests. Only Friedmann (1963) and Mans and Peyton (1962) describe Ruby-crowned Kinglets feeding fledged cowbirds, and Lavers (1974) observed Golden-crowned Kinglets (*Regulus satrapa*) feeding a cowbird.

Kinglet clutches commonly contain 5–11 eggs. Since five kinglet eggs are about 150% of the volume of a cowbird egg, and egg volume is an approximation of the energy needs of nestlings (Murton and Westwood 1977), five or more kinglet nestlings require more energy than one cowbird. This, and the observations of kinglets feeding cowbirds, suggest that kinglets may not have problems meeting the energy requirements of a cowbird. Considering the numerous cases of cowbird parasitism known for other host species, however, the 15 records of parasitism do not suggest that kinglets are important hosts. Factors such as well-concealed spherical nests high above the ground (Bent 1949) may give cowbirds few opportunities to parasitize kinglets.

I thank Dan Busby, Gordon Holton, and M. Ross Lein for commenting on early drafts of this manuscript. I gratefully acknowledge Stephen Rothstein for providing me with an important reference, and also for his valuable comments.

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Received 19 March 1980
Accepted 31 May 1980

Northern Record for Three-flowered Avens (*Geum triflorum*) in Manitoba

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Munro, H. L., and D. H. Munro. 1981. Northern record for Three-flowered Avens (*Geum triflorum*) in Manitoba. Canadian Field-Naturalist 95(1): 100–101.

We have documented the occurrence of *Geum triflorum* (Three-flowered Avens) at Flin Flon, 350 km N of its previously known location in Manitoba. Plants were similar in size to those described elsewhere.

Key Words: *Geum triflorum* (Three-flowered Avens), distribution, Flin Flon, Manitoba.

Geum triflorum (Three-flowered Avens, Old Man's Whiskers, Lion's beard) is an erect perennial herb with flowering stems 15–40 cm tall, pinnately compound basal leaves 10–20 cm long, and one to five nodding

flowers 12–20 mm in diameter (Scoggan 1978; Looman and Best 1979). Three-flowered Avens are common spring flowers on the prairies.

On 10 June 1978, a Three-flowered Avens was found growing on the north-facing slope of a railroad right-of-way near Flin Flon, Manitoba (54°47′N, 101°52′W). Flowering stems were 27 cm tall, basal leaves were 15 cm long, and flowers averaged 15 mm across. On 23 June 1979, the site was revisited and two specimens were located, one of which was collected and deposited in the herbarium at Brandon University.

Other herbs which grew along the right-of-way were *Maianthemum canadense* (Wild Lily-of-the-valley), *Smilacina trifolia* (Three-leaved Solomon's-seal), *Heuchera richardsonii* (Alumroot), and *Carex* spp. (sedges). Intermittent clumps of *Cornus stolonifera* (Red Osier Dogwood) and *Rosa acicularis* (Prickly Rose) were also present. The right-of-way was bordered by *Picea mariana* (Black Spruce) forest.

The previous northernmost occurrence of Three-flowered Avens in Manitoba was recorded along roadsides and in clearings in the Duck Mountains (approximately 51°30′N, 100° W), 350 km S of Flin Flon (Scoggan 1957). The species has also been recorded in prairie communities at Prince Albert National Park, Saskatchewan (53°45′N, 106°03′W) and in roadside meadows at Wood Buffalo Park, Alberta (59°57′N, 112°17′W) (J. M. Gillett, National Museum of Natural Sciences, personal communication) as well as on shallow residual soils in limestone outcrop areas beside the Enterprise–MacKenzie River Highway, Northwest Territories (approximately 61° N, 117° W) (Porsild and Cody 1968).

Presence of Three-flowered Avens in the Flin Flon area does not necessarily represent a natural range extension. The vegetation along the right-of-way is characteristic of moist parkland or woodland margins (Looman and Best 1979). Although Three-flowered Avens seeds are probably capable of long-distance wind dispersal, the absence of other species characteristic of prairie communities suggests that Three-flowered Avens was introduced to the area by train. The disclimax characteristics of the limestone gravel and open environment of the railway allowance provided suitable habitat for the establishment of this non-boreal species.

Our measurements indicate that Three-flowered Avens does not decrease in vigor in northerly latitudes. It is also able to overwinter and maintain vitality in the boreal zone provided that suitable habitat is available.

We express thanks to R. C. Rounds of Brandon University for reviewing the manuscript.

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Received 15 May 1980
Accepted 14 August 1980

FARRELL E. BANIM, O.M.I., 1902–1979

On 8 April 1979, with the death of Father Farrell E. Banim, O.M.I., Professor Emeritus of Biology, Carleton University, The Ottawa Field-Naturalists' Club lost one of its oldest and most faithful members. As far back as 1957, in his Christmas letter, Father Banim described himself as "one of the few remaining real old-timers."

He was born in Dublin, Ireland, on 17 October 1902, the son of Farrell P. and Mary J. Banim, and thus a descendant of John and Michael Banim, the 19th-century Irish novelists (a connection which meant a great deal to him). After his early schooling in Dublin, he was graduated in 1924 from the National University of Ireland. During this period he entered the Novitiate of the teaching and missionary order, the Oblates of Mary Immaculate, and was ordained in Rome in 1927. In Rome, he pursued his studies in theology and philosophy and, after gaining his Licentiate, proceeded to Cambridge University in 1928 to earn his B.Sc. and M.Sc. degrees. For many years thereafter, and often facing great difficulties, he continued postgraduate work at the Catholic University of America (Washington, D.C.), and at Fordham and Columbia universities. In 1957 and 1958 he did research in Palaeozoology at the University of Paris, and during the summer of 1957, he worked at the Mediterranean Biological Station.

After his graduation from Cambridge in 1931, he was sent to what was then Ceylon (now Sri Lanka), to teach at St. Joseph's College, Colombo.

In the meantime, in Ottawa, the Oblate Fathers, with more faith than foresight, had founded St. Patrick's College, planned to provide a liberal arts education from first-form high school to university graduation for English-speaking students. The college opened its doors on the eve of the stock market crash of 1929 and the years of the Great Depression. With a commitment of $660 000, a vast sum in those days, it was imperative that a staff of unpaid teachers be recruited from the members of the Order. Among the gifted and dedicated young men to staff the college in those early years was Father Banim, who came to St. Patrick's in 1933 as head of the Science Department, and who was appointed Dean of Arts the following year, forbidding tasks for a man barely 30 years of age.

It was typical of Father Banim that he lost no time in marshalling all available resources. At the college on Echo Drive he built, with his own hands, the work benches, shelves, and cupboards in the first science laboratory, as well as assisted with the installation of the old Bunsen burners and laboratory plumbing. In the same year, he discovered The Ottawa Field-Naturalists' Club, which he immediately joined. The writer, who was, at the time, a member of the Excursions Committee, well remembers a hurried call from the late W. H. Lanceley. "I've a note here to call a Father Banim. I don't know how you address a priest so I'm giving him your number." "Neither do I," answered a very scared committee member. (Despite the extensive work of Frère Marie-Victorin, Frère Alexandre, Father (later Bishop) Vachon, and others, it was still accepted locally that priests and science did not mix.) The call came through, however, with a warm, genial "Hello, could you tell me something about the field-naturalists' club?" He turned up at the next outing and thus began an association with the club and a friendship with both W. H. Lanceley and myself that lasted unbroken through the years. Nobody knew quite what to expect, but we who had visualized a stern, black-robed cleric were totally unprepared for the unorthodox figure riding his bicycle, in old clothes and a battered felt hat.

In 1936 he was first elected to Council and, with the exception of his years in Africa, served until the end of 1966. When pressed to continue, he answered "No. It is time for the young to take over. We have had our day." He had been Second Vice-President in 1941 and 1942, First Vice-President in 1943 and 1944, and President in 1945 and 1946. He carried out his duties with the enthusiasm that characterized all that he did. In December 1971, he was elected an Honorary Member.

In 1936 and 1937, and again in 1940 and 1941, he took part in the Christmas Bird Census, an activity curtailed only by increasing work at the college. Beginning in 1936, the club held regular winter lectures at St. Patrick's, a program that lasted for the following nine years. For many years the college was almost a headquarters for the club, and council meetings, with few exceptions, were held in the Common Room from 1946 until 1957. At the symposium on the "Natural history of McKay Lake based on field excursions," held on 16 November 1943, there was passed a special vote of thanks to the college "for the use of rooms and equipment." Father Banim's personal contribution to the program was contained in his "Review of the freshwater biology of McKay Lake." Indeed it could be said that Father Banim and St. Patrick's College were almost synonymous. At this time he was especially interested in the algae, and using the bellows of an old-folding kodak, photographed a number of local species. One wonders what became of those pictures.

Science teaching during those times of depression and the war years that followed was a vastly different situation from the well-equipped laboratories and libraries of present-day schools and colleges. Micro-

Farrell E. Banim, O.M.I.

scopes were costly and difficult to come by, sources of basic information, particularly of local biology, were much less extensive than those now available. Strasburger, Tansley, Godwin, Bower, Seward, Borradaile, and Ward and Whipple held pride of place on the shelves, and Father Banim's own books were always available to student and club member alike. There are still members who will recall his patched laboratory coat ("I do all my own mending."). They were the days when straight razors and carrots were used to cut sections, and tubs of dogfish preserved in formaldehyde emitted odors that drifted through the corridors to the disgust of the nonscientific academics. The writer still recalls the shocked and disapproving looks of Ottawa's elite as Father Banim waited on the front steps of the stately Chateau Laurier Hotel one lovely June day, burdened with the skull, ribs, and leg-bones of a cow which he had found in an old pasture near Pink Lake. They were the days of the club's bus excursions, and a member, most likely W. H. Lanceley, had agreed to transport Father Banim and his treasures back to the college. Those bones were part of the collection for many years.

The war years were times of great sadness for him as he watched his young students leave the predominantly male college for service overseas, some never to return.

In 1936, 1937, and again in 1941, he addressed the club on "Mosses, lichens and algae" (illustrated with his own slides), "How to know the flowers," and "The

cultural value of nature study." There are still a few of us who remember his reading the passages on "Mosses" and "Lichens" from Ruskin's *Frondes Agrestes*, his reciting of Padraic Pearse's hauntingly lovely *The beauty of the world hath made me sad*, and the lines from Wordsworth quoted in his tribute to the late Rowley C. Frith in *The Canadian Field-Naturalist* Volume 89(4), 1975,

> For I have learned to look on nature
> Not as in the days of thoughtless youth,
> But hearing oft' times
> The still sad music of humanity.

In 1939 he organized study groups which met at the college on alternate Saturdays during the winter. The first of these was the bird group which he led with J. M. Robinson. In 1943 he worked with the moss group, at the same time developing a new interest in arachnology.

Five years later he was appointed Chairman of the Constitution and By-laws Committee, to carry out a long-overdue revision. This was completed and approved by Council the following year and appeared as "The Ottawa Field-Naturalists' Club By-laws — Revised 1949" in *The Canadian Field-Naturalist* Volume 64(2), 1950. When the club celebrated a delayed 75th anniversary in 1955, he served as Chairman of the Council of Former Presidents to arrange the anniversary banquet held on 8 November at Lansdowne Park.

The greater part of 1957 and 1958 was spent at the University of Paris and at the Mediterranean Biological Station. He described his experience in a letter to a friend as "a wonderful year in France," and on his return to Ottawa in December, spoke of his work at the club's annual dinner. Four years later, he was sent by his Order to Roma, Basutoland, to take over the administration of St. Pius XII University College. It was a difficult assignment, demanding organizing and teaching ability as well as the skills of a diplomat. He returned to Canada in 1964, his health impaired by the burden of work and conflict imposed upon him. During his African years, he met Mary and Louis Leakey and spent his brief vacations working at the famous site at Olduvai Gorge, Tanzania. It is not certain whether he had met Teilhard de Chardin, but certainly in his later years his teaching was influenced by the thought of the great Jesuit scientist.

Back in Ottawa he resumed his work at St. Patrick's College and later at Carleton University when St. Patrick's joined Carleton in 1967. In 1973 he was appointed Professor Emeritus of Biology, and continued to lecture on physical anthropology until within a few weeks of his death. Unfortunately, the pressure of his life left little time for writing, and apart from detailed reports to his superiors and an extensive personal correspondence, he seldom recorded his work and observations. His review of Pieter W. Fosburgh's *The natural thing* in *The Canadian Field-Naturalist* Volume 83(3), 1969, was typical of his free, easy style, even to the characteristic comment at the end — "the price, $4.75, is not a bit too much."

He was first and foremost a teacher, patient, understanding but demanding, and this applied to his study groups as well as to his students. Perhaps the influence of his Banim forbear, John, who was artist and drawing teacher as well as writer, had something to do with his insistence upon all work being accompanied by careful and accurate drawings. A master of the English language, both written and spoken, he refused to tolerate careless or sloppy notes. (It might be added here that he was also fluent in his native Gaelic, French, and Spanish, and toward the end of his life had hoped to retire to the Oblate Mission at Lima, Peru, where he had already spent some time, with the intention of perfecting his knowledge of Spanish).

But his students came to know another side of him as well. He had a habit of beginning class with one of his endless array of jokes, showing his sharp Irish wit. He also loved to tell stories about personal experiences particularly in relation to his archaeological digs. What his students will probably remember most about his classes, however, is his longtime friend "Mrs. Ples," short for *Plesianthropus*, one of the prehistoric skull models used in the anthropology labs. This nickname was an example of his efforts to bring familiarity to a discipline that can be very complex. By his own words "She will live on in the minds of my students long after I am gone." Among his friends and students there will long survive a legion of "Banim stories." One such concerns an incident in the classroom when he was being needled by a student to express his views on the relationship of religion and the theory of evolution, which was quite irrelevant to the subject of his lecture. In exasperation he removed his clerical collar, flung it across the room, and exclaimed, "Here I am a professor of biology. If you want to discuss religion, come to my office after class!" And there was the winter when he agreed to board in the laboratory, in a large cage constructed by himself, a young crow found on a club excursion to Carlsbad Springs, raised by a member in Westboro, but still too young to release. The results were disastrous in terms of the decibel level of the bird's daily "hymn to the dawn." That year he painted a delightful Christmas card showing the crow, and bearing the limerick,

> I'm a sleek bit of mischief, Jim Crow,
> Whose mind is supposed to be slow,
> So they sent me to college
> To brush up my knowledge
> But my heart is in Westboro.

The unremitting financial struggles of the college

and the inevitable changes, along with the disappointments of his African experience, all took their toll but failed to daunt him. What to many would have been obstacles, to him were challenges. St. Patrick's ceased to exist at the end of the academic year 1978–1979 and with it, Father Banim. A final painful illness forced him to relinquish his course in physical anthropology only a few weeks before the end of term and the closing of the college to which he had devoted so many years of his life. There could be no better epitaph for him than Stevenson's immortal lines . . .

To go on forever and fail and go on again,
And be mauled to the earth and arise,
And contend for the shade of a word
  and a thing not seen with the eyes:
With the half of a broken hope for a pillow at night
That somehow the right is the right
And the smooth shall bloom from the rough: . . .

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News and Comment

Experimental Oil Spills off Baffin Island Approved

Approval for experimental oil spills to take place in the nearshore waters of Baffin Island during the summers of 1980 and 1981 was announced in June 1980. The spills are part of a 4-yr study to assess the impact of oil spills on arctic coasts and to test cleanup measures. The study is to be conducted near the northern tip of Baffin Island on Cape Hatt, 70 km from Pond Inlet, the nearest settlement. All participants in the study are satisfied that the environmental effects of the oil spills will be confined to a very small area.

During the summer of 1980 until freeze-up in October, scientists were to gather baseline data and also to release a small amount of oil on a limited section of shoreline to begin studying the long-term fate of oil on arctic beaches. The major part of the study, however, will take place in the summer of 1981. Up to 275 barrels of oil will be discharged in the nearshore waters of several small bays. About 100 barrels of crude oil will be spilled into one bay, and a similar volume of crude oil with a dispersant, which breaks up oil and mixes it into the water, will be discharged into another bay. A third bay will remain uncontaminated as a control.

In an intensive sampling and analysis program that will continue through 1983, scientists will study the fate of oil in the water and sediments and determine its effects on bottom-dwelling organisms such as seaweed and clams. One aim will be to determine whether ecosystems are damaged more by contamination with an oil-dispersant mixture than by untreated oil. Fishes, birds, or mammals will not be purposely exposed to the oil spills. Bird-scaring devices will be used and project personnel will attempt to ensure that no sea or land mammals enter the shoreline test areas.

The Baffin Island Oil Spill (BIOS) project, initiated by the federal government's Arctic Oil Spill Program, is the culmination of several years of planning. The $4-million project is managed by an international committee composed of representatives from the Department of the Environment, the Department of Indian and Northern Affairs, the Department of Fisheries and Oceans, the Canadian oil industry, the Norwegian government, and the United States Oceanic and Atmospheric Administration. Northern residents have been consulted throughout the planning of BIOS and support the aims of the project; in fact, the test site selected was suggested by the Pond Inlet Council.

Prairie Wildlife Interpretation Centre

"The Prairie Wildlife Interpretation Centre is designed to provide the travelling public an opportunity to experience the uniqueness of the prairies," said federal Environment Minister, John Roberts. The center is located on the Trans-Canada Highway near Webb, Saskatchewan.

With summer students interpreting the region's ecology and the history of man's use of the grasslands, visitors will be shown the full range of grassland characteristics on trails that lead through a wheat field, creek valley, tree grove, and marsh. Some 45 species of mammals, more than 450 species of plants, and up to 270 species of birds have been identified on the 1100-acre (~445-ha) site by the Canadian Wildlife Service.

In addition to an abundance of natural life, the site offers a glimpse of prairie history. Visitors may view sections of the original Canadian Pacific railbed, as well as teepee rings left by pre-European plainsmen.

The Prairie Wildlife Interpretation Centre is the most recent addition to a series of Environment Canada centers designed to provide opportunities for direct contact with natural phenomena, typical of a specific region. The existing four centers interpret (1) the wet interior British Columbia forest, a large freshwater marsh, and the valley environment at Creston, British Columbia; (2) the hardwood forest region and Wye marsh at Midland, Ontario; (3) the migration and population management of Snow Geese at Cap Tourmente, Quebec; and (4) the Atlantic coastal region at Percé, Quebec.

Book Reviews

ZOOLOGY

Conservation of Marine Birds of Northern North America

Edited by James C. Bartonek and David N. Nettleship. 1979. Wildlife Research Report 11. United States Department of the Interior, Fish and Wildlife Service, Washington. ix + 319 pp. Free.

James C. Bartonek and David N. Nettleship brought together a representative selection of the papers presented at the International Symposium on the Conservation of Marine Birds of Northern North America, held in May 1975, in Seattle, Washington. This symposium, which was sponsored by the Natural Resources Council of America, the National Audubon Society, the National Wildlife Federation, and the United States Department of the Interior, Fish and Wildlife Service, was "convened because of a growing awareness that not all was well with our marine birds." Participants included scientists, administrators, conservationists, and many interested lay people. The objectives of the symposium were, in chairman H. K. Nelson's words, "to identify problems and the needed information and programs necessary for the conservation of marine birds of northern North America." From the 22 communications included in this volume, and from I. C. T. Nisbet's summary, it is clear that the symposium succeeded in fulfilling its objectives.

The following subject areas are covered in the papers: (1) the marine environment of birds, (2) the status of marine bird populations, (3) the biology and ecology of marine birds in the north, (4) conflicts between the conservation of marine birds and uses of other resources, (5) programs and authorities related to marine bird conservation, and (6) conservation of marine birds in other lands.

In two papers the environment of marine birds is introduced. In *Long term climatic and oceanographic cycles regulating seabird distributions and numbers*, M. T. Myers of the University of Calgary discusses short-term and long-term influences on seabirds, and the necessity of continuous research. He emphasizes the fact that "seabird ornithologists must not rely on government programs to provide continuous data over a period of years." Instead, he suggests that biologists, governments, and amateurs should combine their resources "so that any one of them can continue the work [of censusing marine birds] if any other element should be incapacitated." In *Sea ice as a factor in seabird distribution and ecology in the Beaufort, Chukchi, and Bering seas*, G. J. Divoky discusses the general effects of sea ice on birds and the specific effects of ice on birds in the western Arctic. He also points out the difference between arctic and antarctic pack-ice systems.

Part 2, on the status of marine bird populations, contains various papers on birds breeding along the arctic seacoasts, in the Aleutian Islands, the Gulf of Alaska, and in British Columbia and Washington State.

Section 3 includes papers on the *Trophic relations of seabirds in the northeastern Pacific Ocean and Bering Sea*, on *Population dynamics in northern marine birds*, and on *Time-energy use and life history strategies of northern seabirds*. M. D. F. Udvardy, in a brief article, describes the *Zoogeography and taxonomic relationships of seabirds in northern North America*. Their distribution in the northwest is presented in a well-organized table.

The social and economic values of marine birds, resource development along the coast, marine birds and commercial fishing, and seabirds and introduced animals are some of the topics covered in the next section entitled "Conflicts between the conservation of marine birds and uses of other resources." J. G. King and G. A. Sanger provide an interesting and timely "oil vulnerability index" for marine-oriented birds; this is especially useful at a time when oiled birds and their cleaning and rehabilitation are an increasing concern for ornithologists not only along the coast, but also along inland waterways.

Programs and authorities related to conservation, in Washington State and in British Columbia, and the petroleum industry's role in marine bird conservation, are the subjects of the next section, while the last part of the book provides an interesting look at conservation in such widely separated areas as Norway, the Danish monarchy (including the Faroe Islands), and New Zealand.

Ian C. T. Nisbet, in his summary of the symposium, stresses that there are many important topics that have not been treated in the papers presented. He calls for more emphasis on the surveying of medium-sized seabird colonies, and for more information on the factors influencing the winter range of seabirds. Nisbet believes that in the future "highest research priority should be given to obtaining basic information on reproductive success and life table data for some representative species" of seabirds. He further underlines the need for long-term studies of a few carefully selected species, so "that we can trace the effect of environmental fluctuation on their performance for a long period." Threats to marine bird populations constitute another line of research, because only threats by introduced predators and by

oil pollution are well documented. Potential threats, such as the drowning of diving birds in fish nets, the dumping of toxic substances, mineral development (both onshore and offshore), and human disturbance resulting from increased industrialization and even tourism (particularly the prospective influx of natural history tours), all of which can have major adverse effects, have to be carefully studied.

Most of the articles are accompanied by well-prepared, informative maps and tables. There are also some useful diagrams. There are only two photographs, of rather poor reproduction, but this, in no way, detracts from the merits of the book. It is regrettable, however, that many other papers presented at the symposium could not be included. Of particular interest would have been R. E. Le Resche's communication dealing with the institutional problems involved in protecting and managing seabirds on an interregional and international basis.

I would recommend this book to anyone interested in marine birds, their environment, and their conservation. Although almost five years have elapsed between the symposium and the publication of this volume, it was well worth waiting for.

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The Insects and Arachnids of Canada
Part 1. Collecting, Preparing and Preserving Insects, Mites and Spiders
Part 3. The Aradidae of Canada (Hemiptera: Aradidae)
Part 4. The Anthocoridae of Canada and Alaska (Heteroptera: Anthocoridae)

By J. E. H. Martin, Ryuichi Matsuda, and Leonard A. Kelton (respectively). 1977, 1977, 1978. Supply and Services Canada, Hull. 182 pp., illus. $3.50 in Canada; $4.20 elsewhere. 116 pp., illus. $4 in Canada; $4.80 elsewhere. 101 pp., illus. $4 in Canada; $4.80 elsewhere.

The first part to appear in this long needed series was Part 2, *The bark beetles of Canada and Alaska*, by Donald Bright, Jr., in 1976, covering the beetle family Scolytidae. Since the appearance of Part 4 and the time of this writing, Parts 5 and 6 have been published on *The crab spiders of Canada and Alaska (Araneae: Philodromidae and Thomisidae),* by C. D. Dondale and J. H. Redner, and *The mosquitoes of Canada (Diptera: Culicidae)*, by D. M. Wood, P. T. Dang, and R. A. Ellis. It is to be hoped that the series will continue to appear at least at its present rate if not more rapidly, for there are a lot of insects and arachnids yet to be covered.

Part 1 appears to be a greatly expanded and updated version of Beirne's earlier compilation, with the addition of photographs as well as more and improved drawings. In the foreword, D. F. Hardwick, Director of the Biosystematics Research Institute, states the two objectives of this publication: "to acquaint amateur entomologists or potential amateurs with the basic methods of obtaining insect and arthropod material and preparing a collection; and to serve as a guide to both amateur and professional entomologists on how to prepare material before submitting it to the National Identification Service of the Biosystematics Research Institute."

The first section, 68 pages in length, is concerned with equipment and methods for collecting, followed by a large section on equipment and methods for preserving and mounting, including microscopical preparations as well. This is a section on general techniques. Storage and care of collections is dealt with next. Most of the remainder of the book treats the insects and arachnids by order, discussing special collecting and preservation techniques pertaining to each order. Three pages are devoted to formulas for preservatives, mounting media, stains, etc., and nearly three pages to references.

This is a very useful book, one of the best of its kind available, which I heartily recommend to beginning amateurs and professionals alike.

Part 3 deals with the Aradidae or flat bugs, also known as fungus bugs, for all but one of the 49 Canadian species feed upon fungi. They are usually found under the bark of dead trees.

The introduction is very brief and is followed by a discussion of structure and terminology. There is a key separating the two subfamilies represented in Canada, each containing one genus and a key for each of the two genera. The key to *Aradus* separates the species occurring in Canada and the adjacent states of the USA. *Aneurus* is represented in Canada by only two species.

The species accounts consist of a description, distribution, a list of associated plants (for most species), and remarks that aid in identification. There is also a spot map for most species. Supplementing the keys, but located at the end of the book, are 15 figures consisting of line drawings, and 15 plates in the form of black-and-white photographs. Reference is made to both figures and plates in the keys. The glossary is

three pages long, followed by two and one-half pages of references. There is no index. I noticed only one apparent error, on page 45, where "Vermont" should probably read "Vernon."

This book will be useful to those with a special interest in the Hemiptera, or true bugs, as will the following publication.

Part 4 is concerned with the Anthocoridae, or flower bugs, of Canada and Alaska. These are also known as minute pirate bugs, for their small size (2–5 mm) and their predacious habits. Of approximately 85 species known to occur in North America north of Mexico, 41, representing 14 genera, are known from Canada and Alaska.

The book begins with an introduction followed by discussions on collecting and preserving specimens, classification, and morphology, and a short glossary. There is a key to the three subfamilies represented in the region covered by the book and keys to the tribes, genera, and species, where required. A total of 123 figures illustrate this publication, consisting of 46 line drawings, 40 scanning electron micrographs, and 37 drawings of the bugs. The species accounts consist of descriptions of each sex, remarks aiding in identification, habitat, and a spot map. At the end of the book is a list of scientific and common names for plants referred to in the text, three and one-half pages of references, and an index. As I mentioned earlier, this book will be of special interest to those with an interest in the true bugs, and they are an interesting group of insects.

Not only is this series useful to the professional entomologists, but it will also serve as an important stimulus to the amateurs and beginning amateurs.

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The Birds and Birders of Beaverhills Lake

By Robert Lister. 1979. Edmonton Bird Club, Box 4441, Edmonton, Alberta. 264 pp., illus. $9.50.

Beaverhills Lake, deep in the Aspen Parkland, 75 km E of Edmonton, is Alberta's Point Pelee for water-loving birds of every size and description: common or accidental, migrant or summer resident. It is one of the few places where, in spring, summer, autumn, or, of course, winter, if you pick your day with reasonable care, you will see no other bird-watchers, and in fact probably not even any other people! At the same time you may be completely mesmerized by the multitudes and diversity of the shore- and water-birds. In early spring you may witness hundreds and often thousands of waterfowl - real wild ones, not their Stanley Park or Toronto Island subspecies — flying to and from their feeding areas, clearing leafless treetops by inches. A month later the shorebirds will have their turn to impress you with their numbers and variety.

Scientific importance of Beaverhills Lake as a breeding area and a migratory stopover was first recognized early in this century by Professor William Rowan. As a result, Beaverhills Lake is probably the best known area, ornithologically, in Alberta. *The birds and birders of Beaverhills Lake* is a popular (narrative) account, a local ornithological history, of this famous lake and the observations recorded on its shores from the time of Rowan to the present. The author, Robert Lister, was Rowan's field technician for over 30 years and is today a pillar of the Edmonton Bird Club.

Much of Lister's story is taken from Professor Rowan's field notes. Rowan's interests were many, from his world-renowned studies on the effects of photoperiod manipulation on migration to his lesser known studies on loon embryology and Alberta waders on the British list. Regardless of his interests, they were always carried out at Beaverhills Lake — capturing juncos or crows, collecting loons, waders et al., or just plain waterfowl hunting, which seems to have been freely intermingled with everything. Over the course of 30 or more years, the exploits and daily undertakings of this scientific and ornithological pioneer are described and quoted.

Thus we have many of the diverse exploits of Rowan from the early 1920s to the late 1950s. Some of these exploits were carried out in the finest detail in a pioneer setting, others failed miserably, but there was always humor in them, for example, the day Rowan backed his car over his shotgun, bending both barrels. "Nothing daunted he simply turned the gun over and backed over it again to straighten them."

In Chapter 7, Lister has concluded the history of Beaverhills Lake as seen through the eyes of Professor Rowan and turns to the records of the Edmonton Bird Club (EBC). In his own words, Lister states that this brought to Beaverhills Lake ". . . a new kind of outdoor enthusiast who was neither interested in collecting birds nor shooting them for sport."

The book's contribution is decidedly historical; its scientific ornithological contents are few. Dates, exact locations, and observers are provided for only some of

the more outstanding records. A checklist of the birds of Beaverhills Lake area appears as an appendix; however, it contains at least one obvious error and a questionable call. Cinnamon Teal, which are omitted, have been recorded from Amisk Creek, just south of the lake. They are also mentioned on p. 231 in the text! Also a single Surfbird and at least one Sharp-tailed Sandpiper have appeared at Beaverhills Lake, and have been photographed and accepted by the Alberta Ornithological Records Committee. Is it anything other than coincidence that the one seen on an outing is fully accepted while the one not seen on an EBC outing is only hypothetical!

On concluding the book, as one who once regularly visited Beaverhills Lake, I was left with many mixed feelings. I was disturbed at much of the wholesale slaughter that went on, of Peregine Falcons being so abundant that "... one settled on Harold's back when he was laying camouflaged for geese. He rolled over and put it up and adroitly dropped it." I was embarrassed by Rowan's frequent racial slurs, and the printing of them is totally inexcusable. I was amazed by the scenes that have not changed with time, e.g., the difficulty in getting around the lake. I was disappointed in the almost total lack of reference to colonial waterbirds which have abounded on the lake for years (cormorants, pelicans, gulls, terns, and herons). Finally I was pleased that except for Greater Prairie Chickens and Whooping Cranes, which are admittedly a large exception, the variety of birdlife at Beaverhills Lake has not changed all that much in 50 years.

To conclude, if you know or have known birding on Beaverhills Lake, the book is a must; it will greatly increase your appreciation of the lake. If you don't know the lake you can perhaps find better things to read or at the very least be ready for a boring series of hunting stories.

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The Peregrine Falcon in Greenland: observing an endangered species

By James T. Harris. 1979 University of Missouri Press, Columbia. 255 pp., illus. U.S. $15.95.

The search for Peregrine Falcon eyries and the detailed observation of one during a summer in Greenland provide the basis for a discussion of peregrines as an endangered species, primarily in North America, from both scientific and humanistic perspectives. In 1972, the author was part of a research team investigating the breeding status of peregrines in western Greenland. The narrative of this book concentrates on his search for eyries and detailed observation of one eyrie during incubation, feeding of young, and to a limited extent the interactions of these peregrines with other birds. Throughout this narrative a variety of aspects of peregrine biology, such as the effect of DDT on populations, nest site selection, and prey utilization, are included to detail the life of peregrines in general rather than just the Greenland population.

The book is enhanced by some accurate and concise summaries of biological concepts, but it also suffers from contradictions in fact from section to section, inclusion of many extraneous details, and some poor summaries of biological concepts. Very understandable treatments of the effects of DDT, Mayr's views of species versus subspecies, and peregrine courtship flights give one an impression that the book adequately covers peregrine biology. Unfortunately, either selective reading or an ignorance of some important peregrine research leaves contradictions throughout the book. The author wants peregrines to be symbols of wild areas and hence at one point emphasizes that they nest in places inaccessible to humans (p. 6), while he later discusses peregrines nesting in cities such as Montreal. Coverage of historic peregrine numbers and their subsequent decline is hampered because it is not dealt with as a unit but is split by a discussion of the effects of pesticides. Also, the 1975 North American Peregrine Falcon Survey (Fyfe et al. 1976, Canadian Field-Naturalist 90: 228–273) is ignored resulting in a biased representation. The inclusion of many mealtime conversations concerning weather, who prefers coffee to tea, and an attempt to feed cheese to a spider often slow the book to a snail's pace and distract the reader from the main theme. The suggestions that mammals are scarce in Greenland because they have few places to hide, that Caribou have antlers to protect themselves from wolves, and that foxes see people as 'idle, furless and itchless' reduce the credibility of the reporting.

The idea of using observations of one population of Peregrine Falcons to popularize the life of this falcon is very good. The execution as shown by the above examples is mediocre, certainly not as the dust jacket suggests, 'a model of scientific accuracy,' or reminiscent of Peter Mathiesson.

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Some Adaptations of Marsh-Nesting Blackbirds

By Gordon H. Orians. 1980. Princeton University Press, Princeton, NJ. 295 pp., illus. Cloth U.S. $18; paper U.S. $7.95.

This is the 14th book in Princeton's Monographs in Population Biology series. It is a compilation of 20 years of research on marsh-nesting blackbirds with an aim to testing and expanding ecological theory through measurements and observations in the field.

The book is well organized into eight chapters. The first is an introduction to the biology of the Red-winged Blackbird (*Agelaius phoenicus*), the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), and Brewer's Blackbird (*Euphagus cyanocephalus*), which are the subjects for most of the studies. A brief outline of the characteristics of the marshes and of the materials and methods complete the chapter.

Next, the marsh is considered in detail as a source of food, cover, and nest sites. This provides background for discussion of the adaptations of blackbirds to the resources available, starting with habitat, territory, and mate selection and finishing with a detailed look at foraging behavior. From this basis of interactions between individual birds and the marshes, a jump is made to population and community patterns that result from these interactions. In the next chapter variability in resource use between populations and species is considered, which leads to a discussion of the implications of this variability in competition and community structure, thus concluding the section on the marsh-nesting blackbirds of western North America.

In the following chapter, the author compares the generalizations molded by north temperate experience with south temperate examples from Argentina. The marshes and the blackbirds are briefly introduced and then foods, foraging, and competition are compared.

The final chapter is a discussion of the adaptations of blackbirds in marshes on a global scale. The significance of the structure of marsh vegetation, avian social systems, island biogeography, and the effect of blackbirds on the phenotypes of odonates are dealt with in turn.

This is not an easy reading book full of novel ideas and evolutionary insights. It consists of ecological theory and subsequent tests in the field, and the problems of collecting data relevant to testing hypotheses are emphasized. The result is a cautious interpretation of voluminous data, accepting some generalities and suggesting alternate tests for others. The complement between field data and theory is the strength of the book. It will be of value to all students of avian ecology.

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The First Ten Years of the Co-operative Breeding Bird Survey in Canada

By Anthony J. Erskine. 1978. Canadian Wildlife Service Report Series 42. Supply and Services Canada, Ottawa. 61 pp., illus. $3.75 in Canada; $4.50 elsewhere.

The Co-operative Breeding Bird Survey (BBS), a project designed to measure annual population changes in birds (especially small landbirds), was initiated in 1966 by the United States Fish and Wildlife Service, with support in Canada from the Canadian Wildlife Service. Annual summaries of the Canadian results have been issued since 1970 (Canadian Wildlife Service Progress Notes, Numbers 15, 21, 26, 32, 38, 45, 60, 74, 84). About 1800 BBS routes (250 of these in Canada) are surveyed each year in North America, mostly by amateur volunteers. Each route consists of 50 "stops" at 0.5-mi (0.8-km) intervals, where all birds seen and heard in 3 min are recorded. Each is surveyed by car, once a year (in June or early July) under standardized conditions. This review is as much about the results of the project itself as about Erskine's report of it.

Of the routes surveyed in both of two consecutive years, about 80% are considered by Erskine as "comparable" (same observer, no major changes in survey date, weather conditions, etc.), and only these are used in determining population trends. For analytical purposes, Erskine divides settled Canada into six ecogeographic regions. (Note: these six regions are not the same as those shown on the report's cover!) Since 1966, BBS data have shown significant population changes in several bird species. These include an increase in Red-winged Blackbirds over much of southern Canada, probably because of increased corn acreage; population changes in several forest-bird species resulting from spruce budworm epidemics, and from spraying programs to control the latter; and short-term declines of some insectivorous birds in eastern Canada because of cold spring weather.

Nonetheless, I am skeptical of some population trends suggested by these analyses. For most of the six regions, the number of comparable surveys (20–30) in

successive years barely permits meaningful statistical treatment; furthermore, only 20 or 30 routes per region may not be a truly representative sample of that region. When analyzing results for all of North America, the United States Fish and Wildlife Service groups BBS routes into only three regions (eastern, central, western). With hundreds of routes in each region, population trend analyses obviously stand on much firmer ground than those for the six Canadian regions used by Erskine.

My most serious criticism of this report is of the graphs of population trends (Figures 4a through 12), which occupy part or all of 14 pages of this 61-page bulletin. Most of these graphs attempt to show similarities in population trends among several species within a region. Although most of these data are also presented in Tables 3 through 8, they do seem worth graphing. Unfortunately, most of these graphs lack any scale to indicate the actual population index values. Even those graphs which do have a scale, e.g., Figure 10a and b) are often cut off well above the zero mark, making the population changes look larger than they really are. To be a little facetious, someone writing an article entitled "How to lie with statistics" could easily pick examples from this report!

A major potential use of BBS data is zoogeographic, i.e., for mapping a species' relative abundance in different parts of its range. In American publications on the BBS (e.g., Robbins and Van Velzen, United States Bureau of Sport Fisheries and Wildlife, Special Scientific Reports (Wildlife) Number 102 (1967) and Number 124 (1969)), many such maps, using different kinds of shading for different levels of abundance, have been published. I was disappointed that Erskine did not include any range maps in his report.

Despite the above criticisms, the BBS has proved to be a worthwhile and popular project, and Erskine's report provides a detailed and thought-provoking summary of the first 10 years' results. I hope these surveys can be continued for many years in the future, because the amount of information one can extract from the results seems to increase almost geometrically with the number of years of coverage.

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The Dragonflies of British Columbia

By Robert A. Cannings and Kathleen M. Stuart. 1977. British Columbia Provincial Handbook Number 35. British Columbia Provincial Museum, Victoria. 256 pp. $2.00.

This is the first of the excellent British Columbia Provincial Museum Handbook series to be devoted to insects, and what better insect group to begin with than the Odonata. Not only are they familiar to all of us but, as the authors point out, they are ". . .among the most ancient of insects . . . ." Although the title of this handbook is *The dragonflies of British Columbia*, it includes the damselflies as well.

The introduction contains a number of sections, first introducing the order Odonata. This is followed by a brief discussion on the dragonfly in Indian culture. In the section on the vanishing marshland the authors refer to the phenomenal destruction of rich aquatic habitats in the Okanagan Valley and point out that ". . . the sizes of dragonfly populations that impressed collectors around Penticton in the 1930's no longer exist." It is to be sincerely hoped that we can learn to avoid this kind of destruction before it is too late.

Also included in the introduction are sections on basic structure, biology, and zoogeography of Odonata. The authors list seven additional species to watch for in the province, and they discuss observing, photography, and collecting of dragonflies, and finally, how to use the book.

The body of the book is made up of the keys and species accounts. There are keys to the larvae as well as to the adults, and the keys are well supplemented with excellently clear line drawings by Robert Cannings. As a further aid to identification there are eight halftone plates by Kathleen Stuart. The species accounts include a synonymy, descriptions, range, distribution in British Columbia, field notes, and a spot map.

The authors admit that their book is based "to a large degree" upon existing publications. They have made this information more readily available, however, and with the addition of their own research have produced an excellent guide to the 80 species of dragonflies known to occur in British Columbia. Along with the British Columbia Provincial Museum, they are to be commended.

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Annotated List of Workers on Systematics and Faunistics of Canadian Insects and Certain Related Groups. Pilot Study for a Biological Survey of the Insects of Canada

By the Secretariat. Entomological Society of Canada, Ottawa. 1977. 107 pp.

This useful little publication, especially to entomologists, consists mainly of an alphabetic list of workers in entomology, giving their addresses, disciplines, and specialties. Included also are current projects of each worker and an indication of his intended involvement in the Biological Survey of the Insects of Canada. A total of 436 workers are listed, and in a supplement published in 1978, thirteen more names were added.

The introduction outlines the origin and purpose of the publication and the method of data acquisition. As well, there is a section on how to use this list. There are three indices, one to locations, one to taxa, and one to ecological groups. The user can easily locate workers in a particular locality, with a certain specialty or with an interest in certain ecological areas, for example, insects of alkaline lakes.

What more can one say? This is a useful publication and an excellent beginning for a biological survey of the insects of Canada.

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Wolves of Minong — their vital role in a wildlife community

By Durward L. Allen. 1979, Houghton Mifflin Company Boston. 544 pp. U.S. $16.95.

Minong is the Ojibway name for Isle Royale. This 544-km^2 island has become well known for its Gray Wolf/Moose studies, now extending into the 22nd year. Durward Allen's book is the third monograph on the subject. Others were written by L. D. Mech, *The wolves of Isle Royale* and by R. O. Peterson, *Wolf ecology and prey relationships on Isle Royale*. Allen has the longest continuous involvement with Isle Royale. He began planning the wolf studies in 1951 and in 1958 initiated field work with L. D. Mech as his first graduate student. Mech was followed by five other principal field workers (graduate and post-graduate students) all under Durward Allen's direction. It is therefore appropriate that this book, designed for biologists, naturalists, environmentalists, game administrators, visitors to the park, and outdoor enthusiasts should be written by the master himself.

The title of the book is misleading as the subject is less about just wolves and their role in a vital community as it is about the total Isle Royale ecosystem. That includes such items as redpolls feeding on birch seeds, nesting behavior of birds of prey, and the many nuances in the weather patterns.

The story begins with a speculative account of how the first wolves could have wandered over an ice bridge onto the island. The rest is a detailed descriptive account about the principal subjects, namely human investigators, Gray Wolves, Moose, and the many other components in the ecosystem. In an eloquent style his writing guides the reader through the park. Allen always maintains a perspective on the total scene (the whole of nature as he calls it), never giving up an opportunity to share with us this keen sense of observation. I found a great deal of satisfaction in reading about those things which field workers often observe but which are rarely seen in print. Descriptions of the existence of "moose jumps" ("elk jumps" in our studies), evidence of the spurting of arterial blood on vegetation at kill sites, and the habits of ravens utilizing food remains in wolf scats are but a few examples. Photographs are well chosen and bring the Isle Royale scene into the living room of the reader.

For those interested in purely technical information this book may be disappointing. Durward Allen's treatise does not shy away from technical information, but more importantly his work has a philosophical theme to it. I was impressed by the author's broad visions and the insights that these provided. Because there is an emphasis on the broader picture some biological details have fallen between the cracks. The concept of surplus killing, for example, was used incorrectly; an error frequently made by wolf researchers. References are heavily oriented towards classical studies of the past, with less emphasis on more recent findings. There are numerous typographical errors and one annoying misspelling of an author's name repeats itself; however, these are minor shortcomings.

We can learn a lot from the Isle Royale studies. First and foremost is the need for long-term research. Allen, on page 369, states "a weakness of ecological research in its first 50 years has been the short term approach." Had the Isle Royale studies ended after 10 years the results and conclusions would have been different than was the case after the second 10 years, or alternatively what would have been the conclusion

if studies had begun 10 years later and then ended? Secondly we find out (page 90) that wolf/prey systems are in rough equilibria — "in the operation of ecosystems we see repeatedly that calamitous extremes of almost any kind are countered by compensations. The high-to-low fluctuations tend to even out in a pattern that spells survival over long time periods for all kinds of life that fits the local organization." Thirdly, given a lack of human interference, predation on ungulates is a vital biological process. The scene is ever changing and ultimately habitat and winter severity so far have determined the course of events. Anyone reading this book will understand that there never will be a final outcome. In the meantime this book stands as an important reference on a fascinating subject.

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Mammals of the Eastern United States

By William J. Hamilton, Jr., and John O. Whitaker, Jr. 1979. Cornell University Press, Ithaca, New York. 346 pp., illus. U.S. $19.95.

This revision of Hamilton's 1943 edition treats 105 species of land mammals which occur east of the Mississippi River. The preface states that species naturally inhabiting this area are described, but three introduced species of *Lepus* and the nutria are also included. About 65% of these 105 species also occur in eastern Canada.

In the first edition, 253 species and subspecies were considered with each receiving a separate description and range map. In the current edition, the authors state that an excessive number of eastern subspecies has been described and follow the proposal of Whitaker (The Biologist 52: 12–15. 1970) that a biological definition be used for subspecies as well as for species. The omission of subspecies treatments in the present work allows emphasis on habits rather than on the taxonomy of mammals and increases the value of the work for naturalists and amateur ecologists.

The species accounts contain the following: (1) a verbal description including measurements and usually a drawing or photograph, (2) a statement on distribution and a range map, (3) a discussion of the species habits. Keys to identification, which are included throughout the text, often use skull and dental criteria, but skull characteristics are not included in the species descriptions. The lack of a glossary or any general treatment of the mammal skull may make the keys difficult to use by those unfamiliar with mammalian anatomy.

This is an attractive volume; the species accounts are interesting to read, and the maps, photos, and drawings are clear. Much information in the accounts is inadequately documented, however. For example, it is stated that recent studies indicate *Vulpes fulva* to be the same species as the old world *Vulpes vulpes*, but no citation is provided. *Blarina brevicauda* and *B. carolinensis* are treated tentatively as separate species without citing pertinent studies such as Ellis et al. (Journal of Mammalogy 59: 305–311. 1978). The unsupported statement that *Clethrionomys gapperi* is an agile climber differs from the results of Getz and Ginsberg (Animal Behavior 16: 418–424. 1968) in which an absence of significant arboreal behavior in this species was reported. Much of the literature cited is old; 52% of the 83 references predate 1940. The guide to further reading for Rodentia includes 41% before 1940 and only 7% (half of which are papers by Whitaker) since 1970. Whitaker's accounts of *Cryptotis parva* and *Zapus hudsonius* are the only citations from the Mammalian Species series, although many others exist for eastern species. Further, Vaughan's 1972 edition of *Mammalogy* and Walker's 1968 edition of *Mammals of the World* are listed although both occur in new editions (1978 and 1975).

The authors strongly emphasize that much remains to be learned about many eastern mammals and even state that we have added little to the knowledge of many species since Audubon and Bachman's *Viviparous quadrupeds of North America*; however, the text suffers by not including reference to many important eastern studies. Choate's paper (Journal of Mammalogy 54: 41–49. 1973) on *Peromyscus* in New England is not cited nor are any of the many pertinent studies by Getz (for example, Ecology 49: 276–286. 1968). *Microtus breweri*, a probable semispecies found only on Muskeget Island, Massachusetts, and reported on extensively by Tamarin in the 1970s, could have at least been mentioned under *Microtus pennsylvanicus*, but it is not discussed at all.

Many of these deficiencies will not be obvious or important to the amateur reader who wishes to become familiar with the mammals of the eastern United States and Canada. This readable book should increase the public awareness of eastern mammals and may stimulate the further study of these forms.

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Responses of Peary Caribou and Muskoxen to Helicopter Harassment

By Frank L. Miller and Anne Gunn. 1979. Occasional Paper Number 40. Canadian Wildlife Service, Edmonton, 90 pp. Free.

Miller and Gunn have produced a fine example of applied biological research. This publication is a tool. In the face of increasing oil and gas exploration and development in the Canadian Arctic, this volume provides resource managers with a means of developing site-specific management guidelines for the operation of helicopters in areas frequented by large ungulates. In short, their goal was to determine the effects of various types of helicopter activity likely to occur during the construction and maintanence of a pipeline.

The studies were conducted during the summers of 1976 and 1977 on Prince of Wales and Russell islands, Northwest Territories. The authors examined the overt behavioral responses of Peary Caribou (*Rangifer tarandus pearyi*) and Muskoxen (*Ovibos moschatus*) to helicopter harassment. The 1976 field season objectives were to develop techniques for observation and to describe the responses of harassed animals from ground observation sites and from the air. In 1977 more specific objectives led to the examination of the effect of the aircraft's altitude on animal response, animal habituation to overflights, delayed responses to harassment, and animal response to helicopter landings and ground-based work parties.

Of major importance was the determination of an inverse relationship between the response level of the animals and the altitude of the overflights, and of the horizontal distance between the animals and a landing helicopter. Many of the recommendations are based upon this relationship. The statistical rigor employed to analyze the data is impressive. In completing a literature review on the topic, I found no other study that details the responses of free-ranging ungulates to aircraft harassment to the extent found here. Generally, Miller and Gunn found that the responsiveness of cows and calves of both species and of solitary bull Muskoxen, the group size and social organization, the number of calves in a group,the position of the sun and the direction of the wind relative to the flight, the previous activity of the animals, and the terrain are all contributing factors to the level of response exhibited by the harassed animals.

To minimize harassment the authors recommend that minimum flying heights be restricted to 300 m agl (above ground level) from December through April, and that to ensure minimal disturbance during calving and post-calving periods (May–August) aircrafts be restricted to altitudes no lower than 600 m agl. In addition, it is recommended that the 600 m agl minimum flying height be in effect from August through November to prevent harassment during the rut; too, it is during this time that the young animals are building up crucial winter fat reserves. To limit ground harassment they recommend that crews and vehicles not approach the animals and maintain a buffer distance of 1000 m. Camp dogs should not be permitted to interfere with Caribou or Muskoxen, and construction materials that might hamper movement or be hazardous to the animals should not be left on the site. Juvenile Caribou are known to be inquisitive, which makes them extremely vulnerable to harassment and hunting. The important point here, as Miller and Gunn rightly mention, is that ". . . the investigative behavior of young caribou should not be regarded as evidence that the animals will not be subsequently stressed as a result of the encounter with ground crews and vehicles."

The recommendations should be taken seriously, especially in view of the fact that Peary Caribou and Muskoxen are inhabiting areas near the northern limits of their range. The authors report that reproduction is inconsistent and the general physical condition of the animals over 1 yr of age is poor. Consequently, recruitment is low and natural mortality is high. To inflict additional forms of potential mortality-causing agents on a population whose status is at best precarious is simply playing with fire.

The physiological effects of helicopter harassment are not considered. It is known that a harassing stimulus precipitates excitement that is not always detectable. The authors allude to the problem of not knowing ". . . whether animals that did not overtly respond were in fact responding at a physiological level." This is often referred to as active inhibition.

V. Geist (1975. University of Calgary, unpublished report) states that ". . . intense harassment or frequent harassment which imposes a burden on the energy and nutrient supply of the animal can become the so-called alarm reaction." Physiological trauma can be detrimental to an animal's quest for survival. The need for a physiological approach, in conjunction with a behavioral one, is apparent. Telemetric techniques have not, however, been successfully refined to a level that will permit monitoring of physiological responses (i.e., heart and respiratory rate) to harassment of remote populations of wild, free-ranging animals. In the interim, biologists will have to continue to develop sound baseline data with the available techniques.

"Need for further study" is an important section because it outlines the limitations of this study. Miller and Gunn call for increased research into the physiological aspects of harassment, long-term monitoring

programs, and harassment studies during the fall and winter months. It is not known how Peary Caribou and Muskoxen respond to harassment from September to June. The late winter months (March to May) are especially critical, for it is during this period when the animals are in their poorest physical condition and most vulnerable to harassment.

This volume is an important contribution to resource management and is a must for professionals who are faced with the task of developing sound land-use management strategies in Canada's north.

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BOTANY

The Rare Vascular Plants of Saskatchewan

By Robert V. Maher, George W. Argus, Vernon L. Harms, and John H. Hudson. 1979. Syllogeus #20. National Museums of Canada, Ottawa. 55 pp. English and 57 pp. French. Free.

In Southern Saskatchewan the land is mostly flat, fertile, and free of rocks, allowing easy and almost complete exploitation by cultivation. There has been no long-term policy to preserve the diversity of vegetation adapted to our climatic and soil conditions since the retreat of the last great glacier. Now, belatedly, agriculturalists wish that there were natural areas, bench marks, against which change could be measured and the performance of other ecosystems could be judged. Botanists are belatedly trying to take inventories of all the species (the total genetic diversity) existing in the province so that man's impact on environment can be measured.

In the book *The rare vascular plants of Saskatchewan*, after an eight-page introduction is a list of 368 species (in 60 families) which have been reported as rare. The brief note on each species includes the references which identify that plant as rare, lists the herbaria where voucher specimens are located, and comments on habitat, total range, distribution within the province, and status of protection. The list (about 30 pages) is followed by a bibliography (5 pages) and a list of excluded species (unconfirmed, misidentified, or considered too common for inclusion). The text and appendices are in both English and French and between these two sections there are 300 small maps of Saskatchewan (25 pages) clearly showing locations of those 300 species. The list and the maps of species are in alphabetic arrangement but there is a summary of the species by family in taxonomic sequence.

The authors admit that the information about many of the plants in the list is incomplete. They also admit that only preliminary verification of the specimens has been undertaken and that there is real need for field verification of the current status of the populations. Following the Preface the authors make a plea for information, "additions, deletions, comments and corrections," with "as complete documentation as possible."

This reviewer, in spite of a lifetime in Saskatchewan and considerable interest in plants, has never seen many of the species listed in the book. Certain species do occur over a fairly wide range but apparently they are not common and I do not have any evidence to back the suggestion that they are too common for inclusion in this book. Rather than suggesting deletions my first inclination on reading the list was to suggest certain species for possible addition to the list. There are some species which I have always considered rare that are not in this list. I will be considering possible evidence to support such recommendations. The book is valuable because it makes us realize how little we know of the world around us and how rare and precious so many of the species are. The book encourages further study and research and there will be revisions and modifications as our knowledge and understanding grow. Future lists will surely distinguish some species as endangered, and perhaps some as extinct; they will help to locate sites which must be set aside as ecological reserves for the purpose of protecting certain plant species from extinction.

There is no legal protection for any plant species in Saskatchewan, but there are some areas which receive token protection. It is hoped, however, that Saskatchewan's ecological reserves act will soon be operative.

The authors are to be congratulated. The book brings together a large body of information on rare plants of Saskatchewan. It will encourage much additional study. It is essential reading for anyone interested in preserving biological diversity, man's impact on environment, or the establishment and management of ecological reserves to protect habitats essential for the existence of certain rare plants.

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Identifying Grasses: data, methods and illustrations

By H. T. Clifford and L. Watson. 1977. University of Queensland Press, St. Lucia, Queensland, Australia. U.S. distributor Prentice Hall. 146 pp., illus. U.S. $35.

This book presents a fascinating mixture of ideas and information, but anyone looking for an identification manual will be disappointed. It is about grasses, but many of the ideas in it should appeal even to those taxonomists who (to their shame) avoid grasses. The first chapter starts with a discussion of the difference between classification and identification and contains one of the more readable and complete accounts of different types of keys (conventional, directory, and punched card) that I have come across. The use of computers in plant identification is the subject of the second chapter. In both these chapters it is evident that the authors have considerable experience with their subject. They admit that "the potential flexibility of . . . computerized key making . . . seems to us very attractive" yet state very clearly that under certain circumstances, e.g., if only a single key is to be produced, computer key generation is not worth the effort necessary to obtain the data in the appropriate format. Together the two chapters provide a very useful overview and assessment of different concepts of identification keys.

The next two chapters are on a totally different topic: the morphological variation and vegetative anatomy of grasses. The authors make an interesting distinction between racemose spikelets, in which the rachilla is usually prolonged beyond the uppermost female fertile floret, and cymose spikelets in which it is not. "Experience in using our data to generate keys has shown that 'rachilla prolonged beyond the uppermost female fertile floret/not' produces a symmetrical first division for many samples of grass genera." It would be interesting to determine whether the same would be true for samples of Canadian grass genera.

Those who have struggled with grass keys that expect the beginner to recognize as "sterile lemmas" minute hairy appendages or to know intuitively whether a spikelet lacks a glume or a sterile lemma will take pleasure in the statement that "Keys ought not to demand levels of comparative morphological and taxonomic knowledge that most would-be users cannot reasonably be expected to possess."

The discussion of the vegetative anatomy of grasses is particularly interesting, for the authors draw attention to a number of characters not previously considered to be of much significance such as the number of vascular bundles in the midrib (often three or more in panicoid and andropogonoid grasses) as well as indicating that other characteristics often thought to be constant within a genus may in fact be quite variable. They found, for example, that it was not worth recording more than seven types of silica body whereas Metcalfe recognized twenty.

Most of the book is taken up with photographs of epidermal and cross-sectional preparations of different grasses, approximately 120 epidermal preparations and 60 cross sections. To my prejudiced eye (I like grasses) these are beautiful and I am delighted to have such a large array of species represented in one place. The photographs are also used to explain the terminology used. It was interesting to me that the Australian members of the Stipeae seem to be as variable as the North American members.

The last part of the book is taken up by generic descriptions. Their style is best illustrated by a quotation:

"*Agropyron* 1/3/5,6/8/10/12/14/16/18/20/22/23/25,26/28/29, etc." The numbers refer to attributes which are described at the start of the section. For instance, 1/3 means the upper leaves have a ligule (1), and the 3 means that the ligules are membranous. It is obviously not a style that makes for easy reading but it does pack a large amount of information into a relatively small space.

The last chapter presents a summary of the author's classification of Australian grasses. It is an informal summary with some groups given formal taxonomic names (e.g., Stipeae) and others informal recognition (e.g., danthonioids). Although I was glad to see their classification, I found their introductory paragraphs, in which they indicate those areas that are "exasperating" (the arundinoid grasses), and attributes that they suspect may be of greater taxonomic import than has so far been recognized, of even greater interest. The groups were derived with the aid of a divisive polythetic computer program, a fact that is not belabored. The groups formed correspond, so far as I can tell, reasonably well to those accepted by Gould for North American genera.

I recommend *Identifying grasses* primarily to two groups of people: those interested in methods of identification and those interested in the variation that occurs within the grass family. It contains a wealth of ideas for both groups. Those looking for an identification manual for Australian grasses must turn elsewhere.

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Native Trees and Shrubs of Newfoundland and Labrador

By A. Glen Ryan. 1978. Park Interpretation Publication Number 14. Parks Division, Department of Tourism, Government of Newfoundland and Labrador, St. John's. 120 pp., illus. Free.

I have mixed feelings about this booklet. On one hand, it is a very useful handy little reference for amateurs; indeed, as far as park interpretative material in Canada and elsewhere is concerned, it is better than most. On the other hand, it has many weaknesses and inconsistencies which detract from the overall value of the booklet.

In justifying this booklet the author states "In compiling this book frequent reference was made to already published material. But this was inadequate. A considerable amount of original field work and examination of herbarium specimens had to be done to make the study complete." I must confess that, despite the 'inadequacies' of his 44 references, few of which are quoted in the text, he provides no new information either taxonomically or phytosociologically; on the contrary, his treatment falls far short of his references. In addition, he has failed to consult a wealth of well-known local literature and data emanating from phytosociological studies on the flora of Newfoundland and Labrador, which would have given a broader and more realistic insight into the taxonomy, ecology, and distribution of trees and shrubs in the region.

On the premise that they are too difficult to identify, species of the genera *Salix, Amelanchier, Rubus,* and *Cratageous* were avoided. Yet in Appendix A he lists no less than 33 *Salix*, 6 *Amelanchier*, 4 *Cratageous*, and 8 *Rubus* — most of which have been well illustrated in several of the references. I would have preferred to have seen distinctly recognizable species included to give these genera some representation.

In the short superficial key, from which it is assumed that the reader knows the habit of the plant, the plants are divided into trees and shrubs. Beyond this the reader is on his/her own because there are no guiding symbols to let one know where each group of plants begins. Ericaceae, Caprifoliaceae, and Rosaceae, for example, occur sporadically throughout, depending upon whether it is a creeping or upright shrub, so that the order of the plants appears a confused medley. This makes comparisons between species tedious.

The emphasis of the publication is on the illustrations. The habit drawings are of excellent quality. But it is a pity that only a token effort was given to various features of the plants (twigs, leaves, flower structures, etc.). Many are erroneous, others poorly labeled, and yet others are so obscure as to be quite useless for diagnostic purposes. Occasionally the text does not match the illustrations. Comparatively, the scale of some of the illustrations is misleading and often, especially with regard to seeds, size is not given in the text. Some of the more obvious errors are these: failure to note the decussate leaves of *Mitchella repens*; the structure of the male catkin in *Betula michauxii*, seeds of *Pinus resinosa, Betula pumila, B. cordifolia*, and the flower of *Diapensia lapponica* are all incorrect. The illustration labeled fruit in *Juniperus horizontalis*, should be labeled seed (the text described "fruit are bluish, berrylike cones . . ."). Similarly, the illustrations labeled 'fruit' in *Potentilla fruticosa* does not show the fruit at all.

Despite the author's intent to use as much colloquial language as possible the terminology is anything but non-technical; indeed, for any technical subject it would be presumptuous to assume otherwise for a booklet of this sort. Much critical inconsistency arises in the sequence of the descriptive characteristics, and ambiguity persists throughout the text. In comparing like species, ambiguous and erratic treatment is tedious to follow, especially when no diagnostic keys or underlining of differentiating characters are provided.

The habitat and distribution notes need revision. The geographical designations are much too vague even for amateurs. It would have been useful to provide a map of the province outlining the main regions. Since it is a park interpretation publication perhaps a map showing park locations and administrative regions would have served the purpose. Many of the habitat notes, though not erroneous, do not give a true representation.

Park interpretative literature quite often does not measure up to acceptable standards and if my critique serves any useful purpose, it is perhaps to focus attention on common faults which occur in so-called colloquial park literature. Park naturalists must realize that it is not simply enough to provide pleasant illustrations but also precise and coherent texts. Wherever there is doubt that may lead to ambiguity, the desire for colloquialism should be constrained. Ryan, on the whole, has done a commendable job. He has not underrated the skill and intelligence of the serious amateur, and his book is certainly one that most amateurs will enjoy and find useful.

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Vascular Flora of the Southeastern United States: Volume 1, Asteraceae

By Arthur Cronquist. 1980. University of North Carolina Press, Chapel Hill. xv + 261 pp. U.S. $25.00.

Before I opened the cover of this book, I had somehow anticipated the format of the *Intermountain flora* and *Vascular plants of the Pacific Northwest*, other floras with which Arthur Cronquist has been associated. This flora, however, does not contain the same detailed synonomy and citation of types that is found in the Intermountain and Pacific Northwest floras, but follows the format laid down by A.E. Radford et al. in *Contributors' guide for the vascular flora of the southeastern United States*, which is repeated in part, in the preface.

The presentation is essentially that of a classical flora with dichotomous keys and detailed descriptions, habitat, and known geographic distribution within the southeastern states and the adjacent states. Chromosome numbers are given, but there is no indication as to whether these counts were based on material from within the area treated by the flora.

Synonomy is given where names used differ from the four manuals which cover parts of the region treated: Small 1933; Fernald 1950; Gleason and Cronquist 1963; and Radford et al. 1968. Literature citations are provided for recent monographs.

The only awkward feature of the book is the use of abbreviations for the physiographic regions, with which the user must familiarize himself.

The area covered is that part of the forested United States lying east of the prairie and extending north to the southernmost terminal moraines. The aim is to include all of the vascular plants growing outside of cultivation within this region.

The need for a new treatment to replace Small's *Manual of the southeastern flora* has been evident for many years. This first volume of the new *Vascular flora of the southeastern United States* by Cronquist is an excellent beginning for the series, and it is to be hoped that the authors for the remaining families will follow his fine example.

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Ferns of North-western Himalayas

By K. K. Dhir. 1980. In Bibliotheca Pteridologica, Band 1. J. Cramer, Braunschweig, West Germany. 158 pp., illus. DM40.

This book will have little utility for either amateurs or professionals in North America. For the amateur, he is told that there are 264 species in the region under consideration, which is in the states of Jammu and Kashmir. The region is said to be "not rich in variety of ferns" but has 3.3 times as many species (80) as given by Scoggan for Canada. There are no keys, no descriptions, and no illustrations to distinguish these 264 species, so obviously other works will have to be consulted. A Canadian will be glad to see some familiar friends such as *Ophioglossum vulgatum, Osmunda claytoniana, O. regalis, Adiantum pedatum, Cryptogramma crispa, Pteridium aquilinum, Woodsia alpina* (rare), *Polystichum lonchitis, Cystopteris fragilis, C. montana* (rare as usual), *Athyrium filix-femina, Phegopteris polypodioides, Gymnocarpium dryopteris, Thelypteris palustris, Asplenium viride, A. trichomanes*, etc., but these will be insufficient to extrapolate to all the new genera and species in this region. The professional will note that the system of classification is not discussed, but follows a scheme of Mehra presented in 1961. A large amount of space is taken up with a literature citation for the names used, followed by references to floristic works concerning the species in India. The other contribution is to give some ecological notes about each species, e.g., *Osmunda claytoniana*, "very common at high elevations," and some locality data for the collections.

The only light reading is in the first 23 pages, where there is a brief sketch of the climate, soils, vegetation, epiphytes, climbers, forest floor species, ravine ferns, thicket species, lithophytes, water ferns, etc. The writer uses a colorful style which is not often encountered in works such as this, e.g., "The water holding capacity of rocky soils along the roadside is desperately poor"; regarding evergreen ferns, "perpetuating during the snowy period"; regarding epiphytes, "in the forests with lax crown," "their root systems are more prolific and wiry thus anchoring them to the substratum strongly so as to withstand the wind velocity," "leafy liverworts which retain lot of moisture," etc.

The most enjoyable portion of this book is the 20 figures (actually high-quality photographs) of a few species in their natural habitat although this reviewer is not sympathetic to the words "infested with" when viewing a luxuriant growth of a *Polypodium* on a tree trunk.

The 12 pages of bibliography is a good cross section of the world's literature on ferns as it pertains to the ferns of India. These references might be useful to a

worker studying individual species, but to a casual reader they add little because there is no elaboration regarding their significance, and no discussion of their merits for the list of species.

The number of typographical errors is far too large for a science such as taxonomy which prides itself in being painstakingly accurate about minute details.

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ENVIRONMENT

Order in Living Organisms: a systems analysis of evolution

By Rupert Riedl. 1979. Wiley, New York. 313 pp., illus. US $37.50.

This is a curious book. It reexamines nature from an original point of view. The structure of life from molecules to man is studied to detect to what extent order is found in the constituent blocks. The approach, although similar in some respects to systematics, produces quite different results because its goal is not producing phylogenies and classifications, but an understanding of order. The diverse multidisciplinary approach gives a refreshing view of life.

Life, Riedl proposes, is the result of interaction between accident (mutation) and necessity (inheritance). The degree of complexity that evolves can be measured. Information theory $I = i/P$, where I is the amount of information and P is the probability of occurrence of the event i, is applied. From this he develops a measure of order, the determinacy content. The determinacy content for small bacterium, about 10^{11} bits, exceeds the more complicated machines such as the American telephone system by a factor of 5 thousand or 10 thousand. The content of a man is about 2×10^{28} which exceeds the content of all libraries on earth. It would be interesting to compare the content of a child with that of a highly educated person. He does explain the paradoxical difference of 14 orders between the content of our germ cells and those of an adult.

Order theory must involve complex and simple structures like the spinal cord, the tail of a sperm, and chemical processes. As examples of the latter he cites the turning on and off of processes by chemical "switches" including synchronous switches, regulator-repressors, and sequential switches. Complexes of these he calls order-on-order. He believes that there is little chance of complex systems being dismantled or seldom if ever being turned off. However, I can think of one, at least, the loss of eyes in cave fishes. But he does reemphasize the importance of the new building on the old, or transforming the old, in evolution, or more simply, building blocks.

One chapter is devoted to standard part patterns of order. These are structures which agree so well that there is no doubt left of identical determinative laws. Examples range from elementary physical particles through cells and organisms to societies.

In another chapter arrangement of hierarchies of order, their constancy, and variation are examined. As an example of constancy he cites the posterior rectus muscle, little changed in 400 million years of evolution of man from fish. He points out that the burden (complexity), and constancy (duration) of hierarchical blocks are positively correlated, that is, complex structures are likely to persist.

Part of the delight of the book is examining old facts in a new light, the linkage of warm-bloodedness and fur (or feathers), as an example of traditive inheritance in man, "A fish fin is used for playing the piano, an archaic olfactory brain has been adopted to produce logic; and an original torpedo design was manipulated in tetrapods in a bridge design and finally come to be balanced on two legs, these being the behind pillars of the bridge." Enjoyment is also provided by the extent of the author's presentation using examples from history, embryology, and anatomy. The last feature I enjoyed was the philosophical approach. He contradicts, rightly I think those authors who distinguish between rules and laws of nature, for example. Rules to Riedl are imprecisely recognized laws where either accident reigns or further laws of an unknown kind are at work.

Some readers may be unable to cope with the mathematical formulae or German quotations. But there is enough left from which they will still benefit.

Riedl has refreshingly recaptured much old wine in new bottles. This is a book to be recommended to the philosophically inclined or to those who wish to enlarge their horizons.

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The Environmental Effects of Forestry Operations in Alberta: report and recommendations

By the Environmental Council of Alberta, Edmonton. 181 pp., illus. Free.

This report is the published result of a fact-finding mission designed to examine the environmental effects of logging operations in Alberta. It is an erudite synopsis of a series of public hearings held throughout the province, and although broad in scope, it deals with many of the problems confronting resource managers who are responsible for the utilization of public lands.

Major themes include the development of intensive forest management practices which are integrated to represent other resources and interests, improving the administration of public lands, initiation of research (e.g., on multiple-use and integrated land-planning procedures) and improved data collection programs, improvement of planning and construction techniques, and the development of dynamic land-use practices that best serve the natural resources of Alberta.

The volume is divided into four sections. Section one introduces the reader to forestry in Alberta by reviewing forest policy, history, administration, management, and annual operating plans. Section two is an overview of the public hearings. Public concern ranging from soil erosion to fish and wildlife and recreation is presented.

The recommendations, comprising section three, are perceptive, and in most cases useful and well-grounded; this section justifies the existence of the publication. There are 140 recommendations to improve forestry operations in the province. At the risk of failing to give the positive recommendations ample review, and in hope that the following comments will be viewed as constructive criticism, I will dwell upon a few of the weak points in this section.

Recommendation 12 is particularly bothersome. The recommendation states that ". . . the present general regulation of minimum regeneration height of 6 feet or 20 years between cuts seems to be an unwelcome compromise. Conditions between those favoured by industrial foresters and wildlife biologists have been adopted as a province-wide uniform rule when site-specific compromises would solve more problems. However, until fish biologists, game biologists, and foresters can agree on a more appropriate set of figures these should be retained . . . The Council recommends that portions of each forest (area to be determined by fish biologists, game biologists, and foresters) be handled under different rules to suit the relevant prime uses . . ." Prime use means land-use management through the development of zones, a concept that does not allow for the equal expansion of other resources. Sound management is to develop a guideline system flexible enough to change with the natural dynamics of the forest systems. This requires site-specific evaluation on behalf of all of the interest groups, culminating in comprehensive guidelines governed by a time schedule that dictates the implementation of appropriate action.

The prime-use concept assumes a two-cut cycle, which is unacceptable to me, as a biologist, especially in view of our knowledge of wildlife habitat requirements and modified cutting procedures. Current practices involve clear-cutting 50% of the mercantile timber within watersheds in cutblocks on the first cut. The second or residual cut 20 years later (or after 6 to 8 ft (1 ft = 0.3048 m) regeneration on the initial cutblocks) is not conducive to climax forest-dwelling species (e.g., Pine Martin, Woodland Caribou, and to a certain degree, Wolverine and Grizzly Bear). Generally, 20-30 ft is the minimum height required for winter cover for some large ungulates. Not only will the loss of old growth habitat eliminate the species restricted to mature and over-mature stands, it reduces the numbers of species which utilize a broad spectrum of habitats.

Recommendation 45 states that Forest Management Agreements (FMAs) associated with new mills should be undersized to promote the establishment of local markets for mill-site wastes. The concept of utilizing mill-site wastes is sound, but to undersize FMA areas can be extremely detrimental to wildlife populations. I contend that to manage effectively for wildlife, longer rotation rates, involving 3- to 4-cut cycles, are necessary. In addition, strategically placed buffer strips of ample area are required to promote and maintain ungulate and furbearer populations. To reduce the FMA areas means to harvest more intensively at the expense of critical wildlife habitat.

Section four contains a forest management map, a map of the fish and wildlife zones and recreation areas, an outline of active research programs, and a glossary.

The book is well worth the reading and is recommended to professional resource managers in all fields.

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Soil Organisms as Components of Ecosystems

Edited by U. Lohm and T. Persson. 1977. Proceedings of the 4th International Soil Zoology Colloquium, Uppsala, Sweden, June 1976. Ecological Bulletins Volume 25. NFR, Stockholm, Sweden. 614 pp., illus. 140 SwCr.

Considering that the soil of North America is one of its greatest assets, and, within normal time spans, a nonrenewable resource, one can only continue to be amazed at the small number of North American scientists studying the biology of soil organisms. This weakness is reflected in the authorship of the articles in this book, for only 11 of this book's 158 contributors are from North America. Twenty of 94 contributions are in languages other than English (usually French).

The editors have divided the book into five sections roughly corresponding to the session order of the Colloquium, the first four of which deal with the following themes: (1) Community structure and niche separation, (2) Soil organisms in nutrient cycling, (3) Plant roots in the soil system, and (4) Simulation models of soil organisms. The fifth section gives summaries of presentations in the Poster Session. There is some overlap between sections, and, at times, a lack of focus among articles within the theme sections.

The first section begins with a description of the organization, distribution, habitats, and food of a wide variety of soil animals, in a well-organized and succinct article by J. M. Anderson. The rest of the section attempts to illustrate aspects of community structure using a wide variety of soil animals (amphipods to proturans).

The second section is an effort to define the role of soil animals in soil quality. Reichle's summary of *Research problem areas* on pp. 152–153 is quite cogent. Biologists and ecologists outside of soil zoology are frequently unaware of the importance of soil fauna as soil modifiers allowing more rapid colonization of soil by microbes, and as regulators of microbial biomass and respiration.

Section 3 concerning plant roots in the soil was a revelation. Soil biologists often overlook the point that from one-half to two-thirds of the organic matter in soil is due to the mortality of plant roots rather than detrital fall onto the soil surface. Probably because of the relatively narrow terms of reference, this section had the best focus.

No recent ecology conference could be considered complete without a section on ecological models, and one is included. Although I would agree with the remarks of P. Berthet that models "oblige us to clarify our ideas," I often feel that the models presented at ecology symposia are divorced from reality and not tested rigorously (i.e., the models are limited by the constraints of the data used to develop them, and as a result are inapplicable to real situations). These comments probably apply to this section, too. The fundamental weakness in attempting ecological models in soil biology is the yawning abyss between what little we know, but need to know, to construct sound models.

The final section contains a mixed bag of 41 short papers. For example, there are brief but excellent articles by Dindal and Levitan on *The soil invertebrate community of composting toilets*, Hagvar and Abrahamsen on *The effect of artificial acid rain on soil organisms*, and Perfect et al. on *The effect of DDT on soil organisms in Nigeria.*

I found several of the discussions following papers particularly useful in exposing weaknesses in methodology and experimental design. The student could read them with considerable profit.

Obviously soil biology is still at the stage where descriptive studies still predominate probably because relatively little is known about even which species comprise a given soil community. Until descriptive problems are substantially solved, experimental studies on the functions of soil animals and communities will continue to lag.

This book is only available as a not very sturdy paperback. It will appeal mostly to students and workers in soil biology, but I can recommend selected readings, including the summary papers of Ghilarov and Satchell, to nonspecialists, and ecologists who look upon the soil as a "black box" in their model diagrams.

This book provides a reasonable reflection of the quality and direction of current studies of soil ecosystems. Even casual reading makes obvious the vast diversity of soil organisms and their myriad interactions. One also becomes aware of the enormous difficulties under which soil biologists labor in sampling the soil environment to construct some idea of what goes on in that nether world under our feet.

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Exploring Nature with Your Child

By D. Shuttlesworth 1977. Abrams, New York (Canadian distributor Prentice Hall, Toronto). 240 pp., illus., U.S. $18.50.

I have experienced the joys and frustrations of exploring nature with children. I had expected to learn from Dorothy Shuttlesworth's volume but have not. The title *Exploring nature with your child* implied to me that the theme revolved around an active participation between parent and child. However, the book is, at best, a passive treatment of this theme. The author does not directly address the problems confronted by the parent with children of different ages, abilities, and interests. Only a few examples of activities that can be undertaken by the parent and child are provided. Most of the book is a superficial survey of the plant and animal kingdom, and the physical or abiotic component of nature is completely ignored.

The author has taken the standpoint that education of the parent is the key to exploring nature with a child successfully. However, information alone is insufficient. Children have an uncanny knack of asking questions that often require complicated answers. The author has provided examples of questions that "your young explorer" might ask but in most cases these questions could even be asked by an uninformed parent. The answers to example questions are not adapted to the special problems of communicating with a child.

The book begins with a discussion of exploring nature in a changing world and following chapters deal with birds, mammals, marine life, fish, reptiles and amphibians, zoo animals, pets, spiders, insects, and plants. The author did not include a preface and concluding remarks are lacking. An index is provided at the back of the book and is convenient to use. Chapters on fish, zoo animals, and pets are interesting and are more appropriate to the theme of exploring nature with a child. The book as a whole, however, has several downfalls that result from poor format, misleading or unclear statements, and inadequate explanations.

Although subsections conveniently divide the text, the titles of the subsections do not always reflect the content. For example, the subsection entitled "Expert excavators–moles and prairie dogs" contained discussions of these as well as the range of marmots, the folklore of groundhogs, and the defence mechanism of the skunk.

The book is profusely illustrated with stunning photographs and artwork that complement and strengthen the discussions in the text. However, the captions accompanying the illustrations are often repetitive of the text and the illustrations are not referenced in the text. This reduces the readability of the book and makes it inconvenient to use.

Misleading or unclear statements occur throughout the book. "The beaver is a builder that wastes no material" (p. 55) is a misleading statement because beavers certainly do not utilize all that they harvest. I think the author intended to say that the beaver is efficient in its utilization of tree parts. Other confusing statements result from poor grammar, such as, "When Spaniards sailed back to Europe taking along some little 'pigs' they had discovered they frequently made a stop at Guinea on the western coast of Africa" (p. 167). The directions to build a birdhouse on page 38 are not easily understood and the accompanying photograph of a birdhouse is not of the same design. An illustration of different life stages of the frog is confusing because it is not properly labeled and the drawings of each stage are not proportionate. Text from at least three paragraphs on pages 86 and 87 is missing.

The author has attempted to illustrate the diversity of nature and in doing so neglects to provide detailed discussions. This limits the usefulness of the book because children often ask questions that require full but simple explanations. For example, the discussion of how a tadpole breathes (p. 132) is not clear and lacks the detail required to explain this very important and basic function.

Although the book is handsomely illustrated and does contain some interesting sections. I would not recommend it to a person that already has a basic understanding of natural history. Parents and interpretive naturalists who are looking for novel ways to explore nature with a child will be disappointed with the text.

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Island Forest Year: Elk Island National Park

By Deirdre Griffiths. 1979. University of Alberta Press, Edmonton. x + 257 pp., illus. $12.50.

Elk Island National Park, 40 km east of Edmonton, Alberta, lies in a southern island of mixed boreal forest. Because of past fires and clearing, this "island forest" is now a subclimax poplar parkland. As the author states, "At first glance Elk Island seems monotonous, . . ." but it does have ". . . an intriguing diversity . . ." It is refreshing that Elk Island maintains this natural diversity on 195 km^2 of land so close to a major metropolis, and while almost surrounded by extensive agricultural lands.

Griffiths states that ". . . for the writer to evolve beyond plain description a place must be experienced day to day . . . Factual observation and recording transcend to empathy when the human becomes an integral element in countless interacting events, many of them fleeting, and fragmentary, and minor, but all facets of a unity." According to the publisher's promotional pamphlet, the book is ". . . to be enjoyed and reread by anyone from the mid-teens on, who has even the slightest interest in the outdoors . . . and the experienced naturalist."

The book has a hard cover with a handsome dust cover depicting some of the wildlife, plants, and habitats of the park. No serious topographical errors were found. The 232 pages of text are indented 9 cm on every page and only 11% of this space is used for illustrations. This is a disconcerting waste of paper considering high book prices and the intended readers who are probably sensitive to waste of resources. The book contains 60 of the author's drawings. These are attractive but undistinguished.

The first chapter is an outline of the park's history and environmental setting. It describes the dominant natural features and provides information of use to most naturalists. Although published in 1979, the author uses only British measurement units without metric equivalents.

The rest of the text contains chapters for each month from December through to the following December. Each chapter describes the events experienced by the author in the field. This design is highly reminiscent of Aldo Leopold's classic, *A sand county almanac* (1949, 1966). Griffiths fails, where Leopold did not, in presenting the unity of natural events. Griffiths does not manage to rise above the fleeting, fragmentary, and minor events she experiences. Repeatedly, there are lists of species and events. She shows little selectivity in the events she records in terms of their significance to the whole. Often she mentions an encounter with an animal or its sign (e.g., a Moose track) without any description of its appearance or why it might be seen, and where and when it was seen. The layman with an interest in ecology probably will not find enough information to develop an understanding of ecological interrelationships. The reader cannot develop an empathy for the natural features described by the author.

Griffith's writing style is tedious, nonstimulative, and difficult. The frequent listing will tire many readers. The poetic style is not suitable for the prose form the author has selected.

The book includes annotated checklists of the mammals, birds, reptiles, amphibians, fish, invertebrates, and plants of Elk Island. This is by far the most useful section of the book. However, her usage of scientific names from J. D. Soper's *The mammals of Alberta* (1964) is somewhat outdated with terms such as *Citellus* spp. and *Euarctos americanus*. The bird checklist is updated to 1978.

There is also a glossary, a bibliography, and an index. The glossary and bibliography will be useful to the layman, although they are not extensive. The index is not complete. Among a list of birds given in the text, one or more may not be indexed. Other omissions can also be found.

Elk Island National Park is a very interesting and accessible area for natural history study and observation. However, there has been a lack of popular literature about this park. It is unfortunate that *Island forest year* has not filled this gap in a readable and informative way. This book would be suitable for public library shelves to be borrowed and browsed. At $12.50 a copy, I cannot recommend this text to naturalists or others as a useful addition to their personal libraries.

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MISCELLANEOUS

Photography and the Art of Seeing

By Freeman Patterson. 1979. Van Nostrand Reinhold Ltd., Toronto, Canada. 156 pp., illus. $12.95.

Freeman Patterson is developing a large reputation as an extraordinary photographer and writer. Images such as those seen in *Canada: a year of the land* have brought Patterson many prestigious awards such as The Hon. EFIAP, and much recognition as a photographer. Patterson's writing ability is clear in the numerous articles published in *Photolife, Photo Canada,* and other popular photographic periodicals. However, it was not until the publication of his recent book, *Photography for the joy of it,* that the public became aware of his combined talents as photographer and author.

Patterson's most recent book is equally as informative and enjoyable as the last. The topic of the present work, that of composition in photography, is abstract and often elusive to describe because of the difficulty in expressing verbally how one feels about a photographic image. Patterson, with an obvious artistic awareness and much technical experience, has developed the ability to bridge the gap between impressionism and technical know-how. The result is a simplistic treatise of an inherently difficult photographic topic.

The text is divided into two parts. In the first half, Patterson introduces the reader to many enlighting concepts of photographic composition. One such concept is what Patterson describes as thinking sideways. This is defined as the process of abandonment of normal photographic standards in search of original composition.

One method of thinking sideways is to make a list of three or four items accepted as essential elements to photography. One such item would be to keep the subject always in focus. The photographer then proceeds to break these rules. Patterson admits that on many occasions the resultant image may not be appropriate. But experimentation is integral to the thinking sideways scheme and is essential to the development of new composition technique.

The second section of the text relates the authors' concepts of sound mental impressionism in composition to the technical limitations of the camera. The knowledge that the camera is not a magic box that captures exactly what the eye sees is germane to improving composition in a photograph. Patterson explains that seeing in photography includes knowing what the camera sees. He describes what the camera actually perceives and how the photographer can use this knowledge to his or her advantage.

A detailed discussion on visual design completes the second portion of the text. Visual design is necessary to make a good image because it is concerned with expressing one's subject in the most effective manner. This discussion is, therefore, very important to all photographers.

This book is applicable to those making wilderness photographs. Nature photographs, especially those of animals and plants, have previously simply attempted to capture the subject in full frame. However, at present these types of shots must be original and even impressionistic to enthuse the modern nature photocritic. Therefore, the ability to see photographically can certainly improve nature photography through introducing original theme and design into the images.

This book is very well presented and therefore highly recommended. The image reproduction is excellent, which is a credit to the publisher; and the text is understandable, which is a credit to the author.

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NEW TITLES

Zoology

Arctic summer: birds in north Norway. 1979. By Richard Vaughan. Buteo, Vermillion, South Dakota. 152 pp., illus. U.S. $17.50.

Birds of the Labrador peninsula and adjacent areas: a distribution list. 1980. By W. E. Clyde Todd. Reissue of 1963 edition with corrections and addendum. Buteo Books, Vermillion, South Dakota. 822 pp., illus. U.S. $70. (New pages available separately U.S. $1 for handling.)

Bright waters, bright fish. 1980. By Roderick Haig-Brown. Douglas and McIntyre, Vancouver. 144 pp., illus. $19.95.

Butterflies and moths of Newfoundland and Labrador: the Macrolepidoptera. 1980. By Ray F. Morris. Report 1691. Agriculture Canada, Ottawa. 407 pp., illus. $15 in Canada; $18 elsewhere.

Catalog of Hymenoptera in America north of Mexico. 1979. Prepared under the direction of K. V. Krombein, P. D. Hurd, Jr., D. R. Smith, and B. D. Burks. Superintendent of Documents, Washington. 3 volumes. 2736 pp. U.S. $78.

Cat behavior: the predatory and social behavior of domestic and wild cats. 1979. By Paul Leyhausen. Translated by B. A. Tonkin. Garland STPM Press, New York. xvi + 340 pp., illus. U.S. $24.50.

*__Charrs: salmonid fishes of the genus *Salvelinus*.__ 1980. By Eugene K. Balon. Perpectives in Vertebrate Science Volume 1. Junk, The Hague. ix + 928 pp., illus. U.S. $210.60.

A country-lover's guide to wildlife: mammals, amphibians and reptiles of the northeastern United States. 1979. By Kenneth A. Chambers. Johns Hopkins University Press, Baltimore. xviii + 230 pp., illus. U.S. $14.95.

Ecology of Great Horned Owls and Red-tailed Hawks in southeastern Wisconsin. 1979. By L. Petersen. Technical Bulletin Number 111. Wisconsin Department of Natural Resources, Madison. 63 pp. No price given.

Evolutionary history of the primates. 1979. By Frederick S. Szalay and Eric Delson. Academic Press, New York. 608 pp., illus. U.S. $43.

The evolution of culture in animals. 1980. By John Tyler Bonner. Princeton University Press, Princeton. x + 218 pp., illus. U.S. $14.50.

The George Reserve deer herd: population ecology of a K-selected species. 1979. By Dale R. McCullough. University of Michigan Press, Ann Arbor. xiv + 272 pp., illus. U.S. $16.

Greenshanks. 1979. By Desmond and Maimie Nethersole-Thompson. Buteo, Vermillion, South Dakota. 272 pp., illus. U.S. $27.50.

†**Handbuch der Vögel Mitteleuropas, Band 9: Columbiformes bis Piciformes.** 1980. Akademische Verlagsgesellschaft, Wiesbaden. 1152 pp., illus. DM208.

†**The Hawaiian Goose: an experiment in conservation.** 1980. By Janet Kear and A. J. Berger. Buteo, Vermillion, South Dakota. 154 pp., illus. U.S. $30.

Herbivores: their interaction with secondary plant metabolites. 1979. Edited by Gerald A. Rosenthal and Daniel H. Janzen. Academic Press, New York. 744 pp. U.S. $59.50.

†**Hydromedusae of British Columbia and Puget Sound.** 1980. by M. N. Arai and A. Brinckmann-Voss. Canadian Bulletin of Fisheries and Aquatic Sciences 204. Supply and Services Canada, Hull. viii + 192 pp., illus. $13 in Canada; $15.60 elsewhere.

†**Innovative teaching in aquatic entomology.** 1979. Edited by V. H. Resh and D. M. Rosenberg. Canadian Special Publication of Fisheries and Aquatic Sciences Number 43. Supply and Services Canada, Hull. 114 pp., illus. $4 in Canada; $4.80 elsewhere.

Mesozoic mammals: the first two-thirds of mammalian history. 1980. Edited by J. A. Lillegraven, Z. Kielan-Jaworowska, and W. A. Clemens. University of California Press, Berkeley. x + 312 pp., illus. Cloth U.S. $35; paper U.S. $9.75.

Museum studies and wildlife management: selected papers. 1979. By R. C. Banks. Smithsonian Institution Press, Washington. Available from Museum of Natural History, University of Kansas, Lawrence. 297 pp. U.S. $2 in North America; U.S. $3.25 elsewhere.

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Predator-prey systems in fisheries management. 1979. Edited by Henry Clepper. Papers from a symposium, Atlanta, July, 1978. Sport Fishing Institute, Washington. viii + 504 pp., illus. U.S. $20.

Proceedings of management of north central and northeastern forests for nongame birds. 1979. Compiled by R. M. DeGraaf and K. W. Evans. U.S. Department of

Agriculture General Technical Publication NC—51. North Central Experimental Station, St. Paul, Minnesota. 268 pp. No price given.

Reindeer and caribou hunters: an archaeological study. 1980. By Arthur E. Spiesse. Academic Press, New York. xiv + 314 pp., illus. U.S. $25.

Reproduction of marine invertebrates. Volume 5, molluscs: pelecypods and lesser classes. 1979. Edited by Arthur C. Giese and John S. Pearse. Academic Press, New York. 392 pp. U.S. $45.50.

Songbirds in your garden. 1980. By John K. Terres. 3rd edition. Clarke Irwin, Toronto. 289 pp. $7.75.

Splendid isolation: the curious history of South American mammals. 1980. By George Gaylord Simpson. Yale University Press, New Haven. x + 266 pp., illus. U.S. $17.50.

†**Toxicity tests for freshwater organisms.** 1979. Edited by E. Scherer. Canadian Special Publication of Fisheries and Aquatic Sciences 44. Department of Fisheries and Oceans, Winnipeg. 194 pp. Free.

Vertebrate ecology in the northern neotropics. 1980. Edited by John F. Eisenberg. Smithsonian Institute Press, Washington. 272 pp., illus. Cloth U.S. $17.50; paper U.S. $8.95.

Wildlife and America: contributions to an understanding of American wildlife and its conservation. 1978. Edited by Howard P. Brokaw. Superintendent of Documents, Washington. x + 532 pp., illus. U.S. $8.50 plus 25% foreign handling.

Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. 1979. Edited by J. W. Thomas. Agricultural Handbook Number 553. U.S. Forest Service, Washington. 511 pp. U.S. $14.

Botany

Algal assays and monitoring eutrophication. 1979. Edited by P. Marvan, S. Pribil, and O. Lhotsky. Schweizerbart'sche, Stuttgart. viii + 252 pp., illus. DM49.

The biology of Canadian weeds: contributions 1–32. 1979. Edited by Gerald A. Mulligan. Publication 1693. Agriculture Canada, Ottawa. 380 pp. Free.

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*__The flora of Canada: part 4, Dicotyledoneae (Loasaceae to Compositae).__ 1979. By H. J. Scoggan. National Museums of Canada, Ottawa. Sold only as 4 volume set (previous volumes published 1978). xx + 1711 pp. $131.

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Responses of plants to environmental stresses. 2nd edition. Volume 1, chilling, freezing, and high temperature stresses. 1980. By J. Levitt. Academic Press, New York. 512 pp. U.S. $29.50.

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An all-season guide to easy hiking around Vancouver. 1980. By Jean Cousins and Heather Robinson. Douglas and MacIntyre, Vancouver. $5.95.

The Arun: a natural history of the world's deepest valley. 1979. By Edward W. Cronin, Jr. Houghton Mifflin, Boston. xii + 236 pp., illus. U.S. $10.95.

Bioengineering for land reclamation and conservation. 1980. By Hugo Schiechtl. Translation and editing coordinated by Nick Horstmann. University of Alberta Press, Edmonton. 400 pp., illus. $30.

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†**Estimation of density from line transect sampling of biological populations.** 1980. By Kenneth P. Burnham, David R. Anderson, and Jeffrey L. Laake. Wildlife Monographs Number 72. The Wildlife Society, Washington. 202 pp., illus. $4.

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Human impacts on life in fresh waters. 1979. Edited by J. Salanki and P. Biro. Papers from a symposium, Tihany, Hungary, September, 1977. Akademiai Kiado, Budapest (distributed by Heyden, Philadelphia). 224 pp., illus. U.S. $22.

Land/wildlife integration. 1979. Edited by D. G. Taylor. Proceedings of a technical workshop, Saskatoon, 1–2 May 1979. Ecological Land Classification Series, II. Environment Canada, Ottawa. 160 pp. Free.

The natural selection of populations and communities. 1980. By David Sloan Wilson. Benjamin/Cummings, Menlo Park, California. xviii + 186 pp., illus. U.S. $12.95.

†**A nature guide to Alberta.** 1980. Edited by David A. E. Spalding. Hurtig, Edmonton. 368 pp., illus. $14.95.

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Bird, beast and flower. 1980. Watercolours by Marie Angel. Poems chosen by Ian Parsons. Clarke Irwin, Toronto. 64 pp., illus. $14.95.

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Directory of Canadian environmental experts. 1980. By Environment Canada. Government Publishing Centre, Hull. $12.50 in Canada; $15 elsewhere.

The earth: its origin, structure and evolution. 1979. Edited by M. S. McElhinny. Academic Press, New York. xvi + 598 pp., illus. U.S. $74.50.

The enduring Great Lakes. 1979. Edited by John Rousmaniere. Norton, New York. xiv + 356 pp. U.S. $12.95.

Energy future. Report of the Energy Project at the Harvard Business School. 1979. Edited by Robert Stobaugh and Daniel Yergin. Random House, New York. xii + 356 pp. U.S. $12.95.

Energy in America's future: the choices before us. 1979. By S. H. Schurr, J. Darmstadter, H. Perry, W. Ramsay, and M. Russell. Published by Resources for the Future by Johns Hopkins University Press, Baltimore. xxviii + 556 pp., illus. Cloth U.S. $30; paper U.S. $10.95.

A fossil-hunter's notebook: my life with dinosaurs and other friends.. 1980. By Edwin H. Colbert. Dutton Canadian distributor Clarke Irwin, Toronto. 288 pp., $19.95.

Gathering what the great nature provided: food traditions of the Gitksan. 1980. Edited by the Book builders of 'Ksan. Douglas and McIntyre, Vancouver. 128 pp., illus. $18.95.

Water resources assessment: methodology and technology sourcebook. 1979. By Larry W. Canter. Ann Arbor Science, Ann Arbor. xxii + 530 pp. U.S. $29.50.

*Assigned for review
†Available for review

Instructions to Contributors

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. As the journal has a flexible publication policy, items not covered in the traditional sections (Articles, Notes, Letters, News and Comment, and Book Reviews) can be given a special place provided they are judged suitable. Readers are encouraged to support regional, provincial, and local natural history publications as well by submitting to them their reports of more restricted significance.

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Please submit, in either English or French, three complete manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals.

Type the manuscript on standard-size paper, if possible use paper with numbered lines, double-space throughout, leave generous margins to allow for copy marking, and number each page. For Articles and Notes provide a bibliographic strip, an abstract, and a list of key words. Articles also require a running head. Generally words should not be abbreviated but use SI symbols for units of measure. Underline only words meant to appear in italics. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. Authors are encouraged to use "proper" common names (with initial letters capitalized) as long as each species is identified by its scientific name once.

Although we prefer the names of journals in the Literature Cited to be written out in full, these may be abbreviated following the **Serial Sources for the BIOSIS Data Base**, published yearly by BioSciences Information Service, Philadelphia, Pennsylvania 19103. Unpublished reports should not be cited here. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

Extensive tabular or other supplementary material not essential to the text, typed neatly and headed by the title of the paper and the author's name and address, should be submitted in duplicate on letter-size paper for the Editor to place in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository.

The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations—Photographs should have a glossy finish and show sharp contrasts. Photographic reproduction of line drawings, no larger than a standard page, are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

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Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it himself or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. The Editor makes the final decision on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality and overall high standards of the journal.

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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 95, Number 2

April-June 1981

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Cover: Mountain Plover photographed at Onefour, Alberta, on 5 June 1979 by C. R. Wershler. For information on the nesting and status of the species in Canada see Article on page 133.

The Canadian Field-Naturalist

Volume 95, Number 2 April-June 1981

Tiger Salamanders (*Ambystoma tigrinum*) and Stocked Rainbow Trout (*Salmo gairdneri*): Potential Competitors for Food in Manitoba Prairie Pothole Lakes

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Olenick, Roberta J., and John H. Gee. 1981. Tiger Salamanders (*Ambystoma tigrinum*) and stocked Rainbow Trout (*Salmo gairdneri*): potential competitors for food in Manitoba prairie pothole lakes. Canadian Field-Naturalist 95(2): 129–132.

Tiger Salamanders (*Ambystoma tigrinum*) were aquatic and coexisted with Rainbow Trout (*Salmo gairdneri*) from May until early August, the first half of the trout growing season, in two Manitoba pothole lakes. Salamanders were benthic and ate *Gammarus* almost exclusively. Trout were mainly limnetic and in May–June consumed mainly *Chaoborus* larvae and *Gammarus*, switching almost entirely to *Gammarus* in July and August. The considerable overlap in diet and only partial segregation in time (season) and space indicate a potential for competition for food. This is probably minimized by differences in mouth size and the plasticity of feeding by trout.

Key Words: *Ambystoma tigrinum, Salmo gairdneri,* diet, spatial and temporal distributions, interspecific competition.

While salamanders have minimal effect on fish productivity in large lakes, their influence in smaller water bodies, where they are abundant, may be considerable (Efford and Tsumura 1973). Densities of Tiger Salamanders, *Ambystoma tigrinum diaboli*, in prairie pothole lakes range from 100 to 364 salamanders·ha^{-1} (Tavarutmaneegul 1978; Meyers 1973). While these lakes do not contain indigenous, commercially valuable fishes, some are currently used for aquaculture of Rainbow Trout, *Salmo gairdneri* (Lawler et al. 1974). Efford and Tsumura (1973) state that, because salamanders can be important competitors for food in fish ponds, the role of salamanders should be considered in the development of aquaculture programs. Thus, the present study was undertaken to describe the diet of Tiger Salamanders in stocked and unstocked pothole lakes, and to assess dietary similarity between salamanders and trout in stocked lakes. Data on mouth size and vertical distribution provided further information on the potential for competition for food between these two species.

Materials and Methods

This study was conducted in 1977 on Lakes 156 and 675 of an aquaculture study area near Erickson, Manitoba (Sunde and Barica 1975). Lake 156 is circular and has a surface area of 6.9 ha, a maximum depth of 1.8 m, and a substrate of soft mud. Aquatic vegetation includes dense mats of *Aphanizomenon flos-aquae, Chara,* and emergent *Scirpus* and *Phragmites*. It contained no trout. Lake 675 is rectangular and has a surface area of 9.7 ha, a mean depth of 2.6 m, and a substrate of mud. Vegetation includes *Cladophora, Myriophyllum, Ceratophyllum, Chara,* and emergent *Scirpus* and *Typha*. A woven polyethylene sea curtain, constructed in late May 1977, divided Lake 675 into approximately equal north and south portions. These were stocked with about 3500 and 10 000 trout·ha^{-1}, respectively.

Salamanders and trout were collected during the spring and summer (Table 1) as specimens for analysis of vertical distribution, mouth size, and diet. Gill nets (3 m deep) varying from 13 to 51-mm stretch mesh were normally used, but in Lake 675 gillnetting was restricted at certain times to accomodate other research programs. Here, some samples for stomach analysis were obtained by seining. Gill nets were examined every 4 h and time of capture and vertical position were recorded. Specimens were preserved in 20% formalin and later transferred to 75% isopropyl alcohol. Mouth width (inside distance between corners of mouth) and mouth length (distance from

TABLE 1—Number and dates of capture of salamanders and trout collected by gill net or seine. Trout were not stocked in Lake 156

	Lake 156		Lake 675	
Numbers captured	12 May – 22 June	18 July – 10 Aug.	18 May 30 June	20 July – 12 Aug.
Salamanders				
Larvae	27	119	23	20
Adults	15	0	70	2
Trout	—	—	91	29

corner to anterior tip of premaxilla) were measured with vernier calipers (±0.1 mm).

Food items were identified to genus wherever possible and numbers in each taxon were recorded. The weight of each taxon was estimated by multiplying numbers eaten by the average weight of an undigested item. The proportion of individuals that had eaten each taxon (frequency of occurrence) was also determined. Parasites, vegetation, and detritus were not included in the analysis. Some taxa were grouped for within- and between-species comparisons of the percentages of number and percentages of weight of food categories eaten. Comparisons were made using Morisita's index, $C\lambda$, of overlap (complete dissimilarity = 0; complete similarity = 1.0) as modified by Horn (1966).

Results and Discussion

Trout were planted in pothole lakes in late May and harvested in October and November. Adult salamanders migrated into lakes in late April and early May before breeding and remained until late July and early August. Larvae were first observed on 13 June and 22 June in Lakes 675 and 156, respectively. Newly transformed salamanders were seen on land on 15 August. Salamanders were aquatic during the first half of the growing season for trout and, therefore, coexistence occurred at a time when the rate of growth of trout was greatest (J. A. Mathias, Freshwater Institute, Winnipeg, Manitoba, personal communication).

Salamanders and trout were caught most often at night with trout mainly taken in mid to upper waters while salamanders were benthic (Table 2). The ratio of the number of salamander larvae in upper and lower portions of gill nets differed significantly ($P < 0.005$, chi-square test with Yates' correction for continuity) between day and night as some larvae moved upwards in darkness. The ratio of salamander larvae in upper and lower portions differed significantly ($P < 0.005$) from that of trout for both day and night samples as did salamander adults and trout with day and night combined.

Gammarus were found in all salamander stomachs and made up over 80% of the number and weight of items eaten. Comparisons between lakes, sampling periods, and adults and larvae revealed high similarity in both numbers and weight of items eaten ($C\lambda > 0.97$). Because there were no intraspecific differences between north and south portions of Lake 675 in the diet of either trout or salamanders, samples from the two portions were combined. In Lake 675 in spring, 73% of the items consumed by trout were *Chaoborus* larvae, but in terms of weight, *Chaoborus* larvae and *Gammarus* were of similar proportion and both items occurred in over 70% of the stomachs (Table 3). The diets of salamanders and trout in Lake 675 in spring were dissimilar. In summer Cladocera and *Gammarus* made up similar proportions of the number of items eaten by trout, but *Gammarus* contributed 69% of the weight of the food and occurred in all stomachs. The diets of salamanders and trout, in terms of weight of items eaten, were very similar during summer (Table 3). The vertical distribution of *Gammarus* in the water column is primarily benthic (J. A. Mathias, personal communication).

Mouths of trout and larval salamanders from Lake 675 in June were similar in width but were longer in trout (Table 4). In July mouth length was similar but mouths of larvae were wider than trout. Adult salamanders had much larger mouths than trout. Mouth

TABLE 2—Comparison of depth of capture in gill nets of salamanders in Lake 156 and salamanders and trout in Lake 675. Upper is top two-thirds, lower is bottom third. No larvae were captured in gill nets in Lake 675 because of restrictions on mesh sizes.

	Lake 156				Lake 675			
	Salamander				Salamander adults		Trout	
	Larvae		Adults					
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Day	3	33	1	6	12	13	10	7
Night	142	186	13	22	25	56	51	19
Total	145	219	14	28	37	69	61	26

TABLE 3—Comparison of diet of salamanders (S) and trout (T) in spring (18 May – 30 June) and summer (20 July – 12 August) in Lake 675. Adult and larval salamanders are combined. l = larvae; p = pupae

	Spring					
	Number, %		Weight, %		Occurrence, %	
	S	T	S	T	S	T
Hirudinea	0.1	0	1.0	0	3.2	0
Cladocera	0.6	7.7	0	0.6	2.2	27.5
Gammarus	85.9	10.9	87.1	38.2	100.0	73.6
Hyalella	0.4	0.5	0.1	0.8		
Corixidae	5.3	0.3	2.4	0.4	24.7	4.4
Dytiscidae (l)	1.2	0.2	6.5	3.3	26.9	14.3
Chaoborus (l)	0.4	73.5	0.4	49.6	15.1	87.9
Chironomidae (l, p)	1.0	5.7	0.2	3.9	18.3	36.3
Other	5.5	1.3	2.5	3.4	—	—
$C\lambda$	0.15		0.59			
	Summer					
Hirudinea	0.3	0.5	7.6	20.6	15.0	34.4
Cladocera	0	42.4	0	1.3	0	62.0
Gammarus	80.3	38.9	87.2	68.9	100.0	100.0
Hyalella	0	4.8	0	2.8		
Corixidae	1.4	0.4	0.7	0.2	40.0	44.8
Dytiscidae (l)	0.1	0.2	0.6	1.0	5.0	13.8
Chironomidae (l, p)	16.8	9.2	3.7	3.0	30.0	62.1
Other	1.0	3.6	0.4	2.2	—	—
$C\lambda$	0.65		0.96			

size limits maximum size of prey taken by salamanders (Dodson and Dodson 1971) and by trout (Hartman 1958). The larger mouth size of salamanders in July, when both species fed on *Gammarus* extensively, may have allowed salamanders to eat larger individuals. While mouth size differences may have been important in Lake 675 in 1977, in general relative mouth sizes of co-occurring salamander larvae and trout depend on time of trout stocking and growth rates of the two species.

The diet of salamanders described here is almost identical with that shown by A. K. Maclem (Freshwater Institute, Winnipeg, Manitoba, unpublished data). He examined 103 adults from 14 lakes in June and 97 larvae from 8 lakes in July in the Erickson area and found 82% of the number of items consumed were *Gammarus*. The extensive utilization of *Gammarus* by trout indicates a potential for competition should *Gammarus* be limited in supply. That stomachs of nearly all individuals of both species were full suggests an abundance of food in Lake 675 in 1977.

The severity of competition for food can be reduced if species feed at different times or in different places. We are uncertain of time of feeding of the two species, but there are differences in places of feeding. Adult and larval salamanders were observed to feed while on the bottom when held in aquaria (A. K. Maclem, unpublished data). Their high frequency of capture along the bottom of gill nets, and the occurrence of vegetation and detritus in 33% of stomachs support this observation. Trout are known to consume benthic prey but they also feed in mid to surface waters as indicated by their position of capture in gill nets, consumption of limnetic invertebrates, and infrequent occurrence (8%) of incidental vegetation and detritus in their stomachs.

Salamanders specialize in eating *Gammarus* on the bottom, and their niche, in terms of food and space, is very narrow. That of trout is much broader and overlaps the niche of salamanders. However, trout are opportunistic, nonselective feeders, and although they may prefer *Gammarus* when available, they are capable of exploiting alternate foods from several places (Johannes and Larkin 1961). In Lake 200, for example, the abundant Brook Stickleback (*Culaea inconstans*) is the major food of trout (Tavarutmaneegul 1978). Nevertheless, there is potential for competition for food between salamanders and trout and this

TABLE 4—Mean dimensions (±99% confidence limits) in millimetres of trout and salamanders from Lake 675. Numbers examined in parentheses

			Salamanders	
Month	Dimension	Trout	Larvae	Adults
June	Body length[1]	112.9±24.33	41.1±22.46	109.4±2.48
	Mouth length	9.1± 0.65 (85)	7.0± 0.84 (23)	15.0±0.43 (70)
	Mouth width	7.8± 0.65	7.9± 0.95	18.1±0.61
July	Body length	144.8±68.67	80.5±16.31	
	Mouth length	11.0± 0.69 (13)	11.0± 0.51 (20)	
	Mouth width	8.7± 1.20	14.7± 1.85	

[1]Body length = fork length for trout and snout-vent length for salamanders.

could cause trout to shift in the food and space dimensions of their niche. The impact of such a niche shift on the production of trout can only be assessed by manipulating numbers of both species within restricted areas and recording their growth. Differences in mouth size and partial segregation along the space, food, and time (season) dimensions of the niche suggest that such an impact on trout may not be great.

Acknowledgments

We thank C. H. Johnston for her assistance in the field; J. Mathias and M. Pabst for kindly providing space, facilities, and equipment at the Erickson aquaculture study area along with many useful suggestions during the field study; T. Galloway, I. Lubinsky, and A. Salki for verifying the identification of stomach contents; J. Mathias and A. Maclem for providing their unpublished data; D. I. MacKenzie and D. Marmorek for their helpful suggestions for data analysis; J. Mathias, B. Ayles, W. E. Neill, and A. Copsey for providing constructive comments on the manuscript. The study was funded by a Fisheries and Marine Service grant from the Department of Fisheries and Oceans.

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Received 1 May 1980
Accepted 27 August 1980

Status and Breeding of Mountain Plovers (*Charadrius montanus*) in Canada

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Wallis, Clifford A., and Cleve R. Wershler. 1981. Status and breeding of Mountain Plovers (*Charadrius montanus*) in Canada. Canadian Field-Naturalist 95(2): 133–136.

The first Canadian nesting records of Mountain Plovers (*Charadrius montanus*) are documented, with details of habitat, nest construction, and behavior. All known Canadian records are listed, and recommendations are given for further research and management with respect to this species.

Key Words: Mountain Plover, *Charadrius montanus*; ecology, nesting, behavior, management, distribution, Canada.

Until 1979, there had been few reports of Mountain Plovers (*Charadrius montanus*) in Canada, although Coues (1878) indicated that Mountain Plovers were relatively common along the Canada – United States boundary adjoining southeastern Alberta and southwestern Saskatchewan. Mountain Plovers are inconspicuous and their remote habitat has been seldom visited by naturalists. In this paper we summarize existing records, including the first recorded nestings in Canada. On the basis of our observations of their ecology, we suggest that special land management may be required if Mountain Plovers are to continue breeding in Canada.

Summary of Canadian Observations

While accompanying the United States Northern Boundary Commission in 1874, Elliott Coues (1878) noted Mountain Plovers:

> "in the Milk River Country, along the parallel of 49° [N], where it was breeding in considerable numbers . . . the northernmost points at which the species has thus far been observed . . . it was first seen July 1 (where the Milk River joins the Missouri), and it was traced thence across the country nearly to the Sweetgrass Hills, beyond which it was lost. Its centre of abundance in this region was the vicinity of the Frenchman's River, where many specimens, both adult and young, together with a set of three eggs, were secured during the first and second weeks of July."

The exact location of many of those specimens is unclear, but all were collected within 50 km of the Canada – United States border and some along the boundary itself. The only precise location cited is the crossing of the Milk River (Figure 1), an area very close to the border, where on 23 July 1874 Coues collected one adult.

Soper (1941) saw one bird 5 June 1939 near Bracken, Saskatchewan. He also found four Mountain Plovers near Wildhorse, Alberta, on 22 June 1941. He collected two males there and suspected that they were breeding. That area is slightly rolling with short and mid-grasses as well as scattered sagebrush (*Artemisia cana*) and sparsely vegetated alkaline "blow-outs."

There were no further reports until 12 June 1966, when one of us (CRW) observed two at Elkwater in the Cypress Hills, Alberta. They were not thought to be breeding in this unsuitable habitat. Salt and Salt (1976) noted a report of two Mountain Plovers on 5 July 1971, a few kilometres north of the international boundary about 30 km west of Wildhorse, Alberta. On 22 September 1977, eight Mountain Plovers were seen near Val Marie, Saskatchewan (Peart and Woods 1980). On 30 September 1977, W. Smith and C. Wallis located five Mountain Plovers northeast of Onefour, Alberta. Three of the birds had some buffy coloration on the breast while the other two had clear white breasts, possibly indicating a family group. That site was vegetated with short grasses and had alkaline "blow-outs." It was on a slightly rolling plateau along the edge of an eroding slope, about 100 m above the plains to the south where Soper's Alberta record and our later nesting records were obtained.

Nesting in Canada was first documented 25 May 1979 (Wallis and Loewen 1980). Later, additional nesting Mountain Plovers were found in the vicinity (Table 1). An adult with three eggs was photographed on 5 June 1979 (Figure 2). No birds were observed after 14 July although surveys were made 15 July, 29 July, and 14 August. All three sites are in a remote area between Onefour and Wildhorse, Alberta. Site A lies 100 m west of site B, while site C lies 300 m north of site B. The exact location is not described because we do not want to jeopardize the nesting success of the birds by attracting casual observers.

Habitat and Nest Descriptions

The general habitat around the nests at sites A and B was heavily grazed winter pasture with a recent burn

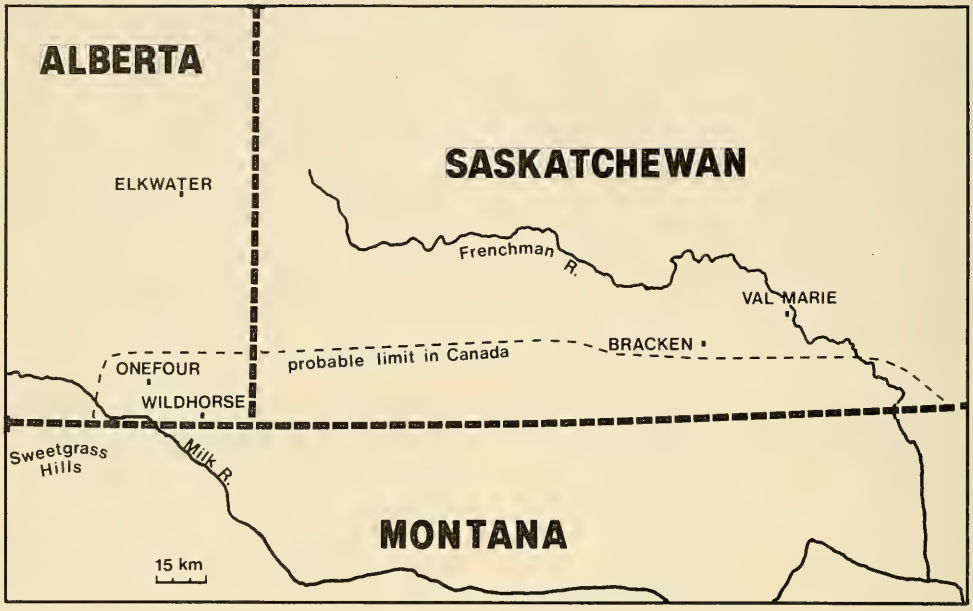

FIGURE 1. Location of place names mentioned in text. Broken line indicates probable breeding range of Mountain Plovers in Canada.

characterized by short green growth. There was taller denser vegetation in the adjacent unburned areas and in more moist depressions within the burn. It is on moderately rolling terrain near a drainage. Vegetation cover at ground level was estimated on 2 × 2 m plots centered on each nest, 14 June 1979. Nomenclature for the vascular plants follows Moss (1959).

Site A is on a slight incline facing south. The vegetation cover was as follows: *Bouteloua gracilis* (Blue Grama) 30% and *Carex filifolia* (Thread-leaved Sedge) 10% with minor amounts of *Eurotia lanata* (Winter Fat), *Carex eleocharis* (Low Sedge), *Cymopterus acaulis* (Plains Cymopterus), *Stipa comata* (Spear Grass), *Plantago purshii* (Pursh's Plantain),

TABLE 1—1979 observations of Mountain Plovers near Onefour, Alberta

Date	Site	Number of adults	Number of eggs	Number of young[a]	Observers[b]
25 May	A	1	3	—	VL, CB,NW, WN, CW, NK, MF
	B	1	—	—	
4–5 June	A	1	3	—	CRW
	B	1	3	—	
	Between A and B	2	—	—	
9–10 June	A	1	3	—	RW
	B	1	3	—	
	Near C	1	—	1 n	
14 June	A	1	—	3 n	CW, CRW
	C	1,1	—	3 n, 3 n	
11 July	A	1	—	2 u	CW, CRW
	C	2	—	3 u	
	C (from B)	1	—	—	
14 July	C	3	—	—	WS

[a]n, newly hatched young; u, unfledged young.
[b]CB, C. Bradley; MF, M. Fairbarns; NK, N. Kondla; VL, V. Loewen; WN, W. Nordstrom; WS, W. Smith; CW, C. Wallis; RW, R. Wershler; CRW, C. Wershler; NW, N. Woerns.

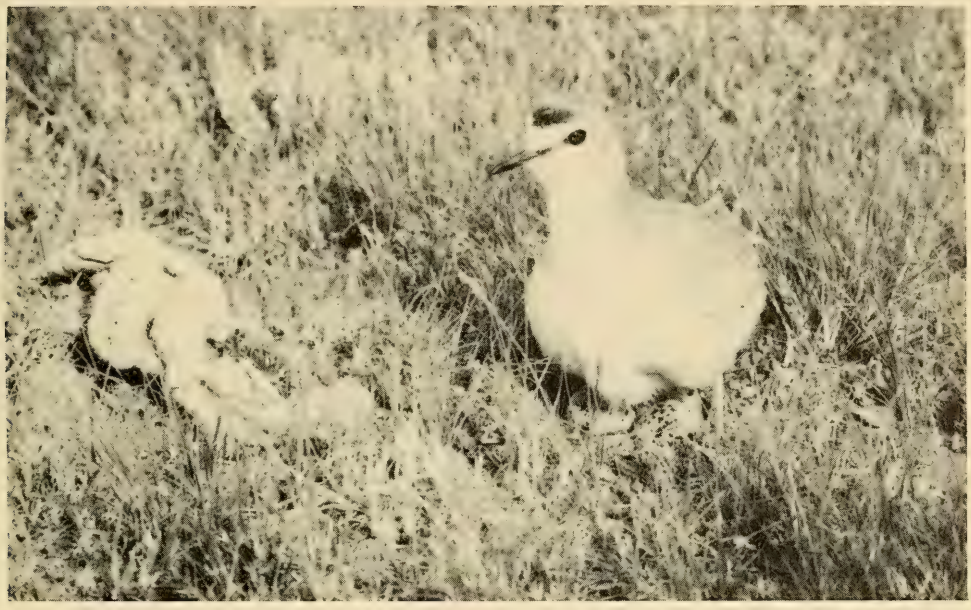

FIGURE 2. Mountain Plover at nest, site B, 5 June 1979. Note the cow manure pile on the left.

and the lichens *Parmelia chlorochroa, Caloplaca* sp., and *Candelariella* sp., with 55% bare sandy loam soil. Other plants nearby included: *Allium textile* (Prairie Onion), *Atriplex nuttallii* (Salt Sage), *Astragalus pectinatus* (Narrow-leaved Milk Vetch), and *Poa secunda* (Sandberg's Bluegrass).

Site B is on a gentle northwest slope. It was characterized by: *Bouteloua gracilis* 25%, *Carex filifolia* 15%, and *Poa secunda* 5% with minor amounts of *Carex eleocharis, Cymopterus acaulis, Eurotia lanata, Allium textile,* and the lichens *Physconia muscigena, Parmelia chlorochroa, Fulgensia sp., Cladonia* sp., *Caloplaca* sp., and *Candelariella* sp., with 45% bare sandy loam soil.

Both nests were located within the burned area and less than 10 m from its edge. At site C there were more weedy species and a higher proportion of mid-grasses (*Stipa comata, Koeleria cristata* (June Grass), *Poa secunda*). Detailed vegetation analysis was not undertaken here as the exact location of the nests could not be determined.

The nest at site A was located beside two large heaps of dried cow manure. The shallow nest depression was lined mostly with pieces of dry cow manure and very small twigs, including broken stems of *Eurotia lanata*. There were also *Cymopterus acaulis* seeds, *Selaginella densa* (Little Club-moss) cuttings, and pieces of the lichens *Physconia muscigena, Cladonia* sp., and *Fulgensia* sp. Another lined nest depression, identical in material, shape, and size, was located a few metres east of the site A nest. It was assumed to be a nest from a previous year; although Mountain Plovers construct several scrapes before nesting, only the actual nest is lined (Graul 1975).

The nest at site B was located next to a group of dry cow chips and a coyote scat. It was lined mostly with pieces of dry cow manure and some old lagomorph (probably *Lepus townsendii*) droppings.

Vocalizations

Several vocalizations similar to those described by Graul (1974) were noted. One, a low guttural sound, was commonly given by the adults when near young. It was a ventriloqual descending call that may be Graul's brood call. However, unlike Graul's verbal description, this call was sufficiently loud to attract us to adults from a considerable distance.

Discussion

Four Mountain Plovers nested at the study sites in 1979. It is possible that these represented two pairs because the male and female frequently incubate separate clutches of eggs simultaneously (Graul 197-). At least nine young were hatched from sites A and C. The fate of the eggs at site B was uncertain.

All observers have noted that the best habitat for Mountain Plovers is extensive unbroken grassland with very short native grass (< 8 cm) at the start of the

nesting season. This is usually Blue Grama (*Bouteloua gracilis*) or Buffalo Grass (*Buchloe dactyloides*), but some areas have a mixture of short grasses, sedges, mid-grasses, and some shrubs. Most good habitat is subject to heavy summer grazing. In the Colorado studies 90% of nests were on slopes less than 2%, usually on large flat areas (Graul 1976).

The Canadian nesting habitat appears to be generally similar to that in the United States, although Buffalo Grass does not occur within the presumed breeding range of Mountain Plovers in Canada. Nest materials used in Canada also were similar to those in Colorado (Graul 1975). Extrapolating from Graul's (1975) and our data, the Alberta birds arrive about the 2nd or 3rd week of April and begin laying in the 2nd or 3rd week of May. The old lined nest depression near site A indicates that the birds may return to a site if habitat conditions remain suitable, as found also by Graul (1973).

We and a few others have travelled extensively in extreme southeastern Alberta on foot and by car, looking specifically for Mountain Plovers and other unusual plants and animals in the region. Unless one is close to a pair of Mountain Plovers, their presence is seldom obvious, and other nesting populations may have been overlooked. There is also a large and little studied area from the Alberta border to Val Marie, Saskatchewan. From the historical records and recent observations, the most likely breeding areas are within 15–20 km of the Canada – United States border between the points where the Frenchman and Milk rivers cross the international boundary, including the proposed Grassland National Park area.

The Mountain Plover is now absent or rare in many areas where previously it was numerous. In Wyoming, there are only isolated populations, and Skaar (1975) documents only five recent breeding locations in Montana. The stronghold of the species is in northeastern Colorado where there is still prime habitat on the Pawnee National Grassland (Graul 1976).

The recent nesting records in Canada probably do not represent freak occurrences. Although the species is at the extreme edge of its range, the Mountain Plover may have always been a characteristic species of this region. It should be added to the list of Canadian endangered species and afforded protective management because of apparent declines in its total world population. The appropriate management of extensive blocks of native grassland, such as those at the Milk River Canyon and at Val Marie–Killdeer, may be crucial to the long-term survival of Canadian populations of the Mountain Plover and other grassland species.

Mountain Plover habitat can probably be destroyed by inadequate grazing. To simulate the range of conditions that must have existed when bison grazed the plains, a balance is needed between heavily grazed, lightly grazed, and ungrazed areas. There may be danger in current trends to uniform grasslands caused by long-term overgrazing, reduction in pasture size, even distribution of cattle use by fencing, watering, and salting, or by totally protecting large areas from all grazing. The key to the preservation of the Mountain Plover probably lies in maintaining substantial patches of short grass in extensive native mixed grassland areas. Locally prescribed heavy summer or late winter grazing or the use of fire may be beneficial, judging from the use of winter pasture and recent burns in the Canadian sites. More research is needed to determine: (1) the extent of the Canadian range and approximate population size; (2) whether habitat is the major limiting factor and whether prescribed burning or various grazing prescriptions could improve habitat; (3) whether climatic changes alter Mountain Plover habitat; (4) more details of their breeding biology in Canada; and (5) wintering areas and how conditions there affect Canadian populations.

Acknowledgments

We express our appreciation to W. Smith and R. Wershler for their field notes and their dedication to field surveys; N. Kondla for review of the manuscript; and B. Peart for details of his recent Saskatchewan observations.

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Received 23 May 1980.
Accepted 20 September 1980.

Estimates of the Standing Stocks of Fishes in Four Small Precambrian Shield Lakes[1]

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Fraser, J. M. 1981. Estimates of the standing stocks of fishes in four small Precambrian Shield lakes. Canadian Field-Naturalist 95(2): 137–143.

Estimates of the standing stocks of fishes in four small Precambrian Shield lakes ranged from 35.2 to 50.8 kg/ha at the time of reclamation with a fish toxicant. In three lakes with similar species composition, White Suckers (*Catostomus commersoni*) comprised 50% (49–62), Golden Shiners (*Notemigonus crysoleucas*) 18% (13–25), and planted Brook Trout (*Salvelinus fontinalis*) 14% (11–17) of total standing stocks. In the fourth lake, Pumpkinseeds (*Lepomis gibbosus*), Brown Bullheads (*Ictalurus nebulosus*), and planted Brook Trout contributed 58, 19, and 13%, respectively, of the total standing stock of 50.7 kg/ha. The relatively rigorous proportionality among species, evident for both communities, and the similarity of their standing stocks of fishes suggest that the carrying capacities of the lakes had been reached.

Key Words: biomass, Precambrian Shield, reclamation, standing stocks, toxicant.

Although there is considerable information concerning the yields of fishes from lakes on the Precambrian Shield (Ryder 1965; Fraser 1972; Adams and Olver 1977; Martin and Fry 1972), much less is known about the size and composition of the standing stocks of fishes in these lakes. This information is important to fish managers because it provides a measure of the productivity and carrying capacity of such waters.

When a lake reclamation project was conducted in conjunction with a research program, it provided an opportunity to estimate the population of fishes in four small lakes on the Precambrian Shield. Three lakes, Sawlog, Pine, and Lonesome (45.35° N, 75.05° W), form the headwaters of a small watershed that empties into the Madawaska River, a tributary of the Ottawa River. The lakes were not fished until a hydro power transmission line provided access in 1950. Initial angling attempts were unsuccessful and according to two highly experienced fishing guides the lakes were devoid of fish, even minnows, before 1950. Preliminary gillnet surveys in 1950 caught nothing, corroborating these observations, at least for the larger fish. A complete survey of the lakes was not, however, conducted at that time. Annual plantings of hatchery-reared Brook Trout (*Salvelinus fontinalis*) began in 1950 and during the following 5–7 years provided reportedly excellent angling. The quality of the angling declined thereafter and in 1961 when the lakes were selected for special study, small Brook Trout were being caught on a put-take basis at the rate of 0.2 fish per hour. Surveys conducted in 1961 showed that all lakes supported the White Sucker (*Catostomus commersoni*), five cyprinid species, and the Brook Stickleback (*Culaea inconstans*). An exception was Sawlog Lake, the headwater, in which suckers did not appear until 1962. The above three lakes were treated with a fish toxicant in July 1968. The fourth lake, Redpine, is the headwater of an adjacent watershed, and it was treated in July 1969. In this paper the standing stocks of fishes at the time of reclamation are described.

The study lakes range in area from 3.6 to 16.4 ha and in maximum depth from 6.1 to 11.9 m (Table 1). Their waters are slightly acidic, poorly buffered, and relatively infertile. Total dissolved solids ranged from 31 to 40 mg/L. Sawlog, Pine, and Lonesome lakes were thermally stratified at the time of poisoning, with thermoclines located at 3–6 m in depth. Dissolved oxygen content of the bottom waters was 0–2 mg/L. In contrast, only a weak temperature gradient existed

TABLE 1—Physical and chemical characteristics of study lakes. Water sampled in 1961–1967

	Sawlog	Pine	Lonesome	Redpine
Area (ha)	6.3	16.4	3.6	8.3
Maximum depth (m)	8.5	11.9	6.4	6.1
Mean depth (m)	4.3	4.6	2.8	2.4
Secchi disc visibility (m)	4.3	3.4	2.7	4.1
Total dissolved solids (mg/L)	31	40	15[a]	39
Total alkalinity (mg/L)	9	11	5[a]	13
pH	6.9	6.8	6.5	6.9

[a]Data from 23 May 1967 — R. A. Ryder data files.

[1]Contribution No. 79-17 of the Fisheries Branch, Ontario Ministry of Natural Resources, Maple, Ontario

in Redpine Lake and the bottom waters were moderately warm (14° C) and nearly saturated with oxygen. Fish species in the three connected lakes were identical and are listed with their scientific names in Table 2. Redpine Lake differed from the others in species composition (Table 2).

Methods and Materials

Several weeks before reclamation, fish were captured, marked, and released in the study lakes. The trap nets used were 1.2 m deep and were constructed of nylon 25-mm mesh (bar measure) in the crib and 32-mm mesh in the leader. The 1.8-m-long Windermere traps were constructed of 6.3-mm mesh hardware cloth attached to three 0.8-m steel hoops. Captured fish were anesthetized with tricaine methanesulfonate (MS222), finclipped, and released. White Suckers, Pumpkinseeds, and Brown Bullheads were measured (fork length) to the nearest 2.5 mm (0.1 in.) before being released.

Marked yearling Brook Trout had been planted in all lakes 1–4 d before poisoning to serve as an index to the recovery of earlier yearling plantings. These "index" trout were not included in the standing stock estimates.

The fish toxicant containing 2.5% rotenone, 2.5% synergist, emulsifier, and a water-miscible solvent was distributed chiefly by slow discharge into the prop wash of two outboard motor boats which slowly crisscrossed each lake. In the two deeper lakes, about 25% of the toxicant was pumped through a weighted hose reaching 6 m beneath the surface. Several small streams and bog areas were sprayed by hand pump. Sawlog, Pine, and Lonesome lakes were treated with a 1.0 mg/L concentration on 3, 9, and 11 July 1968, respectively. Redpine Lake received a 2.0 mg/L concentration on 7 July 1969. Although the lakes were treated separately, the method of treatment and the subsequent collection of fish was similar for all the lakes.

The application of the toxicant was completed by noon and the collection of fish, which began within 30 min of the beginning of treatment, continued throughout that day and the following day. Five or six two-man crews working from small boats or canoes dipnetted dead and dying fish from the surface of the lake and along the shore. The collection was discontinued after 2 d in Sawlog, Pine, and Lonesome lakes because few fish surfaced thereafter. Fish continued to surface in Redpine Lake and were collected over a 5-d period. Small fish that had drifted to shore were collected with difficulty in areas of aquatic vegetation and overhanging shoreline shrubs.

The fish collected were sorted by species, examined

TABLE 2—Numbers and weights of various species of fish collected from four lakes following treatment rotenone

	Sawlog		Pine		Lonesome		Redpine	
Species	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
Brook Trout[a] (*Salvelinus fontinalis*)	215	12.9	301	16.7	90	4.9	517	37.6
White Suckers (*Catostomus commersoni*)	474	35.8	1806	40.6	426	17.7		
Golden Shiners (*Notemigonus crysoleucas*)	1239	15.9	4092	17.1	636	2.6		
Creek Chub (*Semotilus atromaculatus*)	167	2.9	136	5.2	10	0.3	P[b]	
Pearl Dace (*Semotilus margarita*)	240	2.2	111	1.0	33	0.4	P	
Redbelly Dace (*Chrosomus eos*)	P		P		360	0.9	P	
Fathead Minnows (*Pimephales promelas*)	251	0.9	11	—	21	0.1	P	
Brown Bullheads (*Ictalurus nebulosus*)							1316	28.9
Pumpkinseeds (*Lepomis gibbosus*)							5641	20.9
Brook Sticklebacks (*Culaea inconstans*)	80	0.1	23	—	407	0.3		
Minnows and sticklebacks	684	1.9		5.5		0.6		
All species	3350	72.6	6480	86.1	1983	27.8	7474	87.4

[a]Planted.
[b]P = present but not collected.

individually for finclips, counted, and weighed in the aggregate. Fork lengths of Brook Trout, White Sucker, Brown Bullhead, and Pumpkinseed were measured individually to the nearest 2.5 mm. Small fish, which formed the residue left after collections had been sorted, deteriorated rapidly and were weighed in the aggregate and described "minnows and sticklebacks."

SCUBA divers swam six to eight transects along a measured, weighted line laid on the lake bottom in the afternoon of the day following rotenone treatment. The transect lines, stretching from shore to shore, were perpendicular to the long axis of the lake, and divers, swimming in pairs, collected fish from a 3.7-m-wide strip of bottom. In this manner, 5.8, 2.6, 9.0, and 6.0% of the bottom of Sawlog, Pine, Lonesome, and Redpine lakes, respectively, were searched for dead fish. Bright sunshine aided the divers, and good visibility to a depth of 9 m was reported. Visibility was poor at greater depths and consequently the deeper sector (2.3 ha) of Pine Lake could not be searched. An estimate of the numbers of fish on the entire lake bottom was made by expanding the transect data by direct proportionality. No fish were caught in gill nets (38-, 51-, 64-, 76-mm mesh-stretched measure) set in the treated lakes 5–7 wk after the treatment.

Ratios of marked to unmarked fish in the total collection were used to calculate Petersen-type estimates of the Brook Trout, White Sucker, and Golden Shiner populations. Confidence limits (95%) were calculated using formula 1.13 of DeLury (1951). Estimates of standing stocks were calculated by multiplying the mean weights of each species by their respective population estimates.

Results

Sawlog Lake

A total of 3350 fish weighing 72.6 kg was collected from Sawlog Lake following rotenone treatment (Table 2). The collection was made up of Brook Trout, White Suckers, Brook Sticklebacks, and five cyprinid species.

Estimates of the numbers and weights of the three chief species were made and are presented in Table 3.

TABLE 3—Estimates of the standing stocks of fishes in four study lakes at the time of rotenone treatment

	Number marked and released	Number collected		Population estimate	Confidence levels (95%)	Mean weight (g)	Standing stock	
		Unmarked	Marked				kg/ha	%
Sawlog Lake								
Brook Trout	150	178	37	872	671–1245	60.0	8.3	17
White Sucker (>10.0 cm)	207	432	45	2194	1708–3066	75.5	26.3	53
Golden Shiner (>6.4 cm)	817	905	334	3030	2784–3314	12.8	6.2	13
Minnows and stickleback		920				8.7	8.5	17
Total standing stock							49.3	
Pine Lake								
Brook Trout	250	240	57	1302	1052–1711	55.5	4.4	13
White Sucker (>10.0 cm)	124	1493	17	11014	7430–21277	25.5	17.1	49
Golden Shiner	3388	3227	350	34625	31437–38534	4.2	8.9	25
Minnows and stickleback							4.8	14
Total standing stock							35.2	
Lonesome Lake								
Brook Trout	99	66	24	368	275–571	54.5	5.6	11
White Sucker	84	413	13	2753	1780–6065	41.5	31.7	62
Golden Shiner	845	358	46	7421	5813–10283	4.2	8.7	17
Minnows and stickleback							4.8	10
Total standing stock							50.8	
Redpine Lake								
Brook Trout	200	379	138	749	699–808	72.8	6.6	13
Brown Bullhead (>8.0 cm)	392	1059	140	3357	2898–3990	23.5	9.5	19
Pumpkinseed	1153	5543	98	66368	53307–82960	3.7	29.6	58
Minnows and darters							5.0	10
Total standing stock							50.7	

The most numerous fish was the Golden Shiner, but White Suckers contributed the most weight (53%) to the total standing stock of 310 kg or 49.3 kg/ha. The Golden Shiner population consisted of two distinct size groups, large (>6.4 cm) and small (<3.8 cm). Only the larger Golden Shiners could be captured, marked, and released, and this was the size group most commonly collected after poisoning (Figure 1). Mean weights of marked and unmarked Golden Shiners in the collection were 11.8 and 13.2 g, respectively, indicating that the population estimate of 3030 applies to the larger Golden Shiners which made up 13% of the lake's total standing stock.

An estimated 872 Brook Trout were extant in Sawlog Lake at the time of poisoning. Ratios of the different finclips indicate that 66% had been planted in May, 6 wk before poisoning and the remainder in the preceding autumn.

It was not logistically practical to estimate the populations of small Golden Shiners, four other cyprinid species, and the Brook Stickleback by mark and recovery methods. However, an approximate estimate was made by assuming that the collection of small fish represented about 15% of the standing stock of small fish. Because the mean recovery after poisoning of Brook Trout, White Suckers, and Golden Shiners was 27, 18, and 19%, respectively (Table 4), the assumed 15% recovery of small fish conservatively allows for the reduced effectiveness in collecting them.

TABLE 4—The percentage recovery of marked fish following treatment with rotenone. Duration of pickup was 2 d

Lake	Brook Trout	White Suckers	Golden Shiners	Brown Bullheads	Pumpkin seeds
Sawlog	25	22	41		
Pine	23	15	10		
Lonesome	24	17	5		
Redpine	35[a]			19[a]	8
Mean	27	18	19		

[a]These percentages were increased to 69 for Brook Trout and 36 for Brown Bullheads when the duration of pickup in this lake was extended to 5 d.

Pine Lake

The total standing stock of Pine Lake was estimated to be 35.2 kg/ha made up of 49% White Suckers, 25% Golden Shiners, 13% Brook Trout, and 14% cyprinids and Brook Sticklebacks (Table 3), very similar to the proportionate representation in Sawlog Lake. Most of the Brook Trout were recently planted yearlings.

The estimate of 11 014 White Suckers is an approximation at best because only 124 suckers were marked and released into the population. Apparently, the traps caught the few large suckers in the lake but were ineffective in catching the small ones which comprised 90% of the population (Figure 1). The scarcity of large suckers is likely the result of annual gillnet sampling in

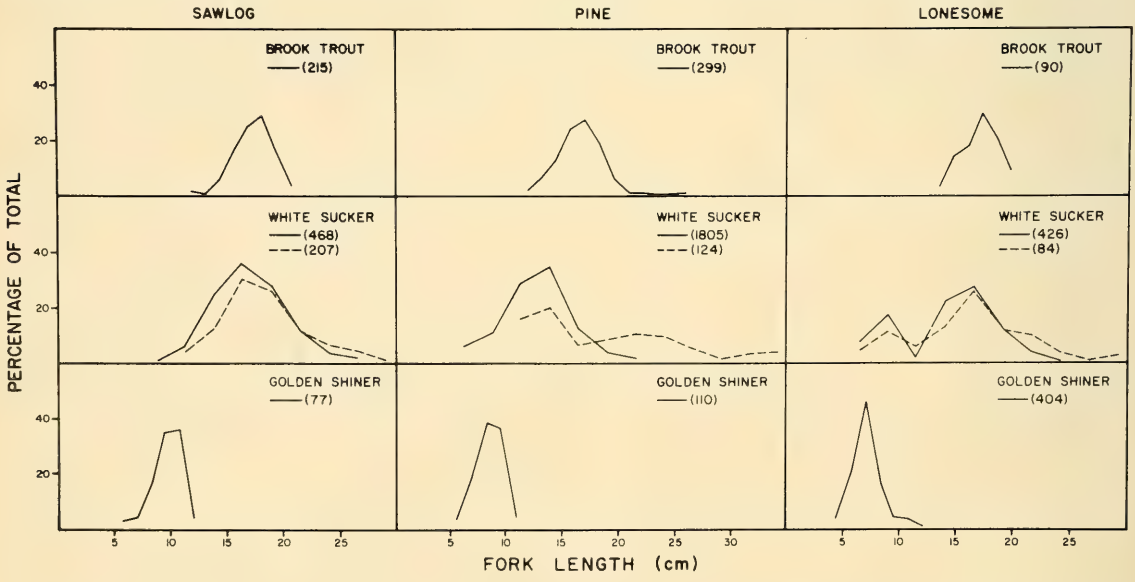

FIGURE 1. Length distribution (solid lines) of Brook Trout, White Suckers, and Golden Shiners collected following the reclamation of Sawlog, Pine, and Lonesome lakes. Broken lines represent fish marked and released before poisoning. Numbers of fish measured are in parentheses.

1963–1967. The estimated population of 34 625 Golden Shiners represented a standing stock of 8.9 kg/ha (Table 3). The collection of minnows (other than Golden Shiners) and sticklebacks weighed 11.7 kg and assuming they represent 15% of the small fish population, their standing stock was 4.8 kg/ha.

Lonesome Lake

Golden Shiners and White Suckers were also the predominant species in the collection of fish from Lonesome Lake. Golden Shiners were most numerous but constituted only 17% of standing stock owing to their small size (mean, 4.2 g). The White Sucker population was bimodal in length distribution with peaks occurring at 8.9 and 16.5 cm (Figure 1). It contributed 62% of the lake's total standing stock of 5.8 kg/ha (Table 3). The remainder consisted of recently planted yearling Brook Trout, small minnows, and sticklebacks.

Redpine Lake

Following treatment of Redpine Lake on 7 July 1969, Pumpkinseeds, Brown Bullheads, and Brook Trout were collected daily to 11 July 1969 (Table 2). Five cyprinid species and the Iowa Darter were noted floating on the surface, but were not collected. The standing stocks of the three chief species were estimated to total 45.7 kg/ha and allowing 5.0 kg/ha for cyprinids and darters, the lakes standing stock of fishes amounted to 50.7 kg/ha (Table 3).

Pumpkinseeds, which constituted 58% of the standing stock, ranged from 2 to 11 cm with the majority falling in the 4- to 5-cm length-class (Figure 2) and weighing 3.7 g on the average. Pumpkinseeds, marked and released from the traps, were larger than those collected after poisoning (Figure 2), but this probably did not affect the population estimates because all sizes floated on the surface after dying and were collected with equal efficiency. Brown Bullheads (>8.0 cm) and yearling Brook Trout made up much of the remainder of the lake's standing stock (Table 3).

Population Estimates Based on SCUBA Transects

On the day following treatment on each lake, SCUBA divers swam six to eight transects along the lake bottom searching for dead fish. The numbers of fish picked up by the divers were extrapolated to the total substrate area to provide estimates of the total number of fish on the lake bottom. This estimate was combined with the number of fish collected on the surface to provide an estimate of the population before poisoning of the lake. Estimates were calculated in this manner for Brown Bullheads in one lake, White Suckers in three lakes, and Brook Trout in all four lakes (Table 5). Petersen estimates of the same populations derived from mark and recovery data are entered in Table 5 for comparison.

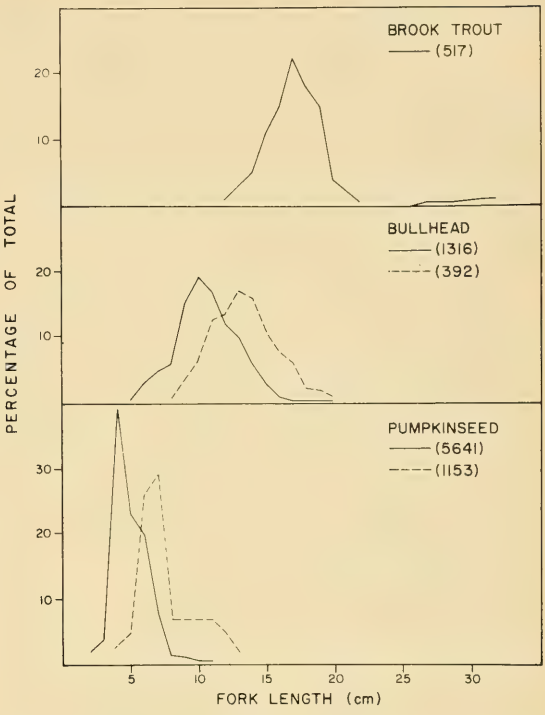

FIGURE 2. Length distribution (solid lines) of Brook Trout, Brown Bullheads, and Pumpkinseeds collected following the reclamation of Redpine Lake. Broken lines represent fish marked and released before poisoning. Numbers of fish measured are in parentheses.

In all instances, the estimates based on underwater transects were significantly lower than the Petersen estimates. A probable explanation is that some dying fish entered the soft organic substrate and died there, out of sight. Estimates based only on fish seen and collected from the lake bottom would, therefore, be biased on the low side.

Divers observed fish with only tails protruding from the lake bottom and suggested that there were probably others completely hidden in the organic ooze. Rupp and DeRoche (1965) reported that dying bullheads apparently had burrowed into the bottom silt during rotenone treatment of Shagg Lake, Maine. Divers in our study reported seeing Brook Trout and suckers, as well as bullheads, with only their tails protruding from the lake bottom.

Discussion

The procedure of marking and releasing fish before lake poisoning, as recommended by Carlander and Lewis (1948), provides for an estimate of percentage recovery in the collection of fish. Appleget (1949) used

TABLE 5—Population estimates of Brook Trout, White Suckers, and Brown Bullheads based on extrapolated bottom collections added to surface collections

	Sawlog	Pine	Lonesome	Redpine
Number of transects	6	8	6	6
Total length of transects (m)	1003	1155	885	1372
Area of lake bottom searched (m^2)	3671	4227	3239	5017
Percent of lake searched	5.8	2.8	9.0	6.0
Brook Trout				
Number estimated on bottom	534	577	100	356
Estimated population				
— bottom estimate + surface collection	718	863	181	599
— mark and recovery[a]	872	1302	368	749
White Sucker				
Number estimated on bottom	672	2692	522	
Estimated population				
— bottom estimate + surface collection	1107	4428	901	
— mark and recovery	2194	11014	2753	
Brown Bullheads				
Number estimated on bottom				1683
Estimated population				
— bottom estimate + surface collection on days 1, 2				2279
— mark and recovery				3357

[a]Mark and recovery estimates from Table 3.

this method and estimated the standing stock of fish in a 4.5-ha softwater lake in Minnesota to be about 88 kg/ha. The procedure was especially useful in the present study because accurate enumeration of dead fishes by direct count was not possible. Shoreline counts were hampered by vegetation and because of poor visibility, counts of fish on the lake bottom were restricted to depths less than 9 m. In addition, some distressed fish apparently entered the bottom ooze and died there, out of sight.

Several of the population estimates are of questionable accuracy mainly because of the difficulty in capturing a sufficient number of fish for marking and release. Hence, the confidence intervals for the estimates of White Suckers in Pine and Lonesome lakes are rather wide. For the same reason estimates of cyprinids (other than Golden Shiners) and sticklebacks could not be made, and it was necessary to use the percentage recovery of other species to make conservative approximations of the standing stocks of minnows. These difficulties could undoubtedly be overcome in future projects by an intensive trapping program using appropriate gear.

Estimates of the standing stocks of fishes in our study lakes ranged from 35.2 to 50.8 kg/ha, somewhat higher than the 14.6 kg/ha determined for Red Deer Lake, 90 km distant (Chadwick 1976). According to Carlander (1955), standing stocks of this order are representative of trout lakes and indicate a low productive capacity compared to warmwater lakes and reservoirs. The poor supply of nutrients to Precambrian Shield lakes is reflected in the low values of total alkalinity (5–13 mg/L) and total dissolved solids (15–40 mg/L) in these waters. Ryder (1965) has shown that a low level of fish production can be expected from lakes of similar fertility. The study lakes, although physically and chemically suitable for Brook Trout, lack adequate spawning areas and consequently cannot support reproducing Brook Trout populations.

The predominance of the White Sucker and rather rigorous proportionality among the three major species in Sawlog, Pine and Lonesome lakes (Table 3) indicates a moderately stable community structure. Adams and Olver (1977) have noted that percid species tend to constitute 30% by weight of the fish yield obtained from communities in which they occur, and they proposed this relation to be an emergent property of that type of community. Our study lakes may represent another type of community and a community conservatism (Kerr 1977) that places the White Sucker in a predominant role, comprising 49–62% of the total standing stock, followed by the Golden Shiner comprising 13-25%. In Redpine Lake, interestingly, although the species composition was different, a corresponding proportionality among species occurred and the total standing stock was approximately equivalent to that of the other three lakes.

Native Pumpkinseed and Brown Bullheads were predominant contributing 58 and 19%, respectively, of the lake's total standing stock of 50.7 kg/ha.

The lakes considered in this study are relatively infertile, of simple morphometry, and support small standing stocks of fish. Because two different fish communities produced standing stocks of similar size, the carrying capacities of the lakes had apparently been reached and intrusion by planted Brook Trout would have been severely limited. This probably accounts for the poor survival of Brook Trout planted in these and similar lakes on the Precambrian Shield (Fraser 1972).

Acknowledgments

I am indebted to K. Buckingham, D. Cucin, J. Murdock, B. Kukhta, and a host of student assistants and volunteers for their assistance in the treatment of the lakes and the collection, examination, and enumeration of the kill of fishes; to R. Ryder, J. Casselman, and C. Olver for reviewing the manuscript.

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Received 26 June 1980
Accepted 23 September 1980

A Test of the Peninsular Effect on Species Diversity

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Taylor, Robert J., and Lee A. Pfannmuller. 1981. A test of the peninsular effect on species diversity. Canadian Field-Naturalist. 95(2): 144–148.

The hypothesis tested was that species diversity declines along peninsulas because of the direct effects of peninsular geometry upon rates of colonization and extinction of local populations. Communities of carabid beetles and small mammals (rodents and insectivores) were sampled at three sites along Red Deer Point in Lake Winnipegosis, Manitoba; this was chosen as a research site from a map of North America solely on the basis of its size and shape. From the samples taken from this 39-km peninsula, we conclude that carabids and small mammals fail to exhibit an identifiable peninsular effect.

Key Words: peninsular effect, Manitoba, small mammals, carabid beetles, species diversity.

Simpson (1964) observed, while studying the geographic distributions of Recent mammals, that species number decreases toward the tips of all major North American peninsulas. This "peninsular effect" has subsequently been discovered in other vertebrate groups as well, e.g., birds (MacArthur and Wilson 1967; Cook 1969), and amphibians and reptiles (Kiester 1971). Simpson suggested that this was not a fortuitous pattern, that the geometry of peninsulas predisposed them to exhibit such a gradient in diversity. The mechanism for this was an equilibrium between local extinctions of species and the colonization of empty habitats, a mechanism familiar to most ecologists by its application to islands. Peninsular faunas living in an approximately linear chain of communities would be relatively more vulnerable to the loss of species near peninsular tips where recolonization was limited and extinction possibly more likely.

The logic and evidence behind this hypothesis were explored in another paper by one of us (Taylor and Regal 1978). The primary conclusion of that paper was that Simpson's reasoning was acceptable; a simulation model of the processes of colonization and extinction did produce appropriate equilibrium patterns, although some rigid constraints were necessary upon both the model's structure and the values of its parameters. Recently Gilpin (in press) has suggested that the model may produce appropriate peninsular patterns under less severe constraints.

Mathematical models yield only suggestions and possibilities, of course. Although a good hypothesis should certainly be internally consistent, logic does not, by itself, constitute a test. Testing of the validity of the peninsular effect is certainly necessary because the second major conclusion of Taylor's and Regal's paper was that the species diversity patterns of vertebrates on all North American peninsulas, with one exception, can be explained more parsimoniously as responses to vegetational change. That exception is Baja California, a puzzling location requiring more attention.

Empirical approaches to the examination of biogeographic hypotheses require either direct manipulation of biotas (e.g., Simberloff and Wilson 1969), or, more traditionally, indirect analysis of natural experiments. Inasmuch as direct manipulation is rarely practical, biogeographic research has relied heavily upon the indirect test of noting the presence or absence of predicted patterns in previously uninvestigated locations. In this paper we report the results of such a test of the peninsular effect. We chose an unexamined peninsula from a map of North America using as criteria only that it be long, narrow, and small enough that it could be sampled.

Study Site and Methods

Red Deer Point, 39 km long, extends into Lake Winnipegosis in central Manitoba (Figure 1). Because Red Deer Point is substantially smaller than Florida, Baja California, Yucatan, and the other major North American peninsulas, we tried to compensate for the effects of scaling down. To do this we looked at two quite different animal groups, small rodents and insectivores which are relatively uniform in dispersal ability, and ground beetles (Coleoptera: Carabidae), a more variable group with some very good and some very poor dispersers. The reason for using an invertebrate group was the success enjoyed by Simberloff in scaling down investigations of island biogeography by looking at insects on Florida mangrove keys (e.g., Simberloff 1976).

The width of Red Deer point ranges from 1 to 5.8 km. It is quite flat, probably no greater than 8 m above the lake at its highest point. The chief topogra-

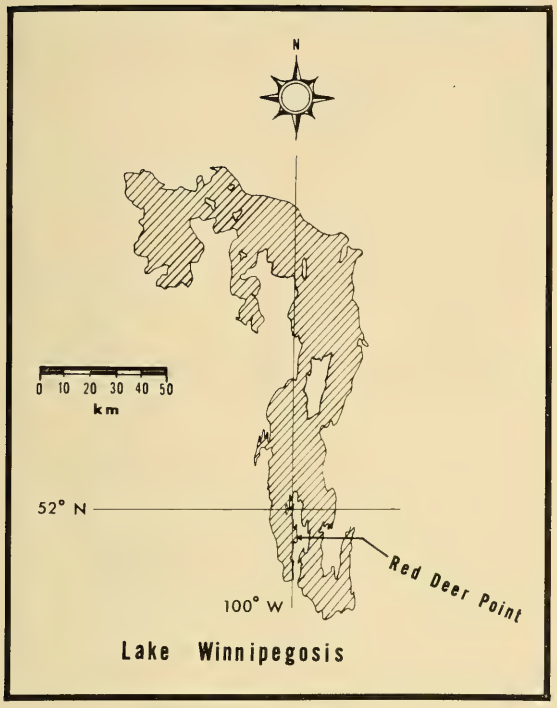

FIGURE 1. Location of the peninsula studied, Red Deer Point in Lake Winnipegosis, Manitoba.

phic feature is a 1- to 3-m-high levee along the lakeshore. Long-term data on the lake's water level are not available; however, local residents, several of whom have been in the area since the 1920s, claimed that the water level at the time of the study was as high as it ever had been.

The vegetation consists of a mosaic of sedge and grass meadows interspersed with second-growth forest. Trembling Aspen (*Populus tremuloides*) dominates the forest, but one finds large numbers of Bur Oak (*Quercus macrocarpa*), White Elm (*Ulmus americana*), Red Ash (*Fraxinus pennsylvanica*), and a few White Spruce (*Picea glauca*). The soil is thin, averaging less than 10 cm. Meadows and woods occur in about equal proportions in the southern half of the peninsula; in the northern half, woods predominate. Nearly all the forest understory is grazed by cattle, although grazing is heavier in the southern half. About one-third of the meadows are fenced and used for hay. The even-aged stands of aspen in the northern third of the point have grown up after intensive logging in the 1920s and 1930s and a major fire in 1949.

We sampled small mammals and ground beetles at three locations along the point in late June and early July of 1975 (Figure 2). The primary study areas were at Glory Harbor and Kristjanson's Farm. At both places small mammals were collected from meadows and aspen woods at each of two sites. Only one woodland site was trapped at Robinson's Bay. Ground beetles were collected at all sites but only in the woods. At Glory Harbor beetle traps were placed in two patches of woods, one of which was nearly pure aspen, the other a mixture of aspen and ash. The dominant understory plant at both sites was *Aralia nudicaulis,* Wild Sarsaparilla. We tried to set traps at both sites in transects spanning the transition from the edge to the interior of the woods. At the time Forest Tent Caterpillars (*Malacosoma disstria*) were defoliating the pure aspen stands. Beetle traps at Kristjanson's Farm were placed in two patches of woods, one of which consisted of a fairly open aspen canopy with a dense ungrazed understory of ash. The second location con-

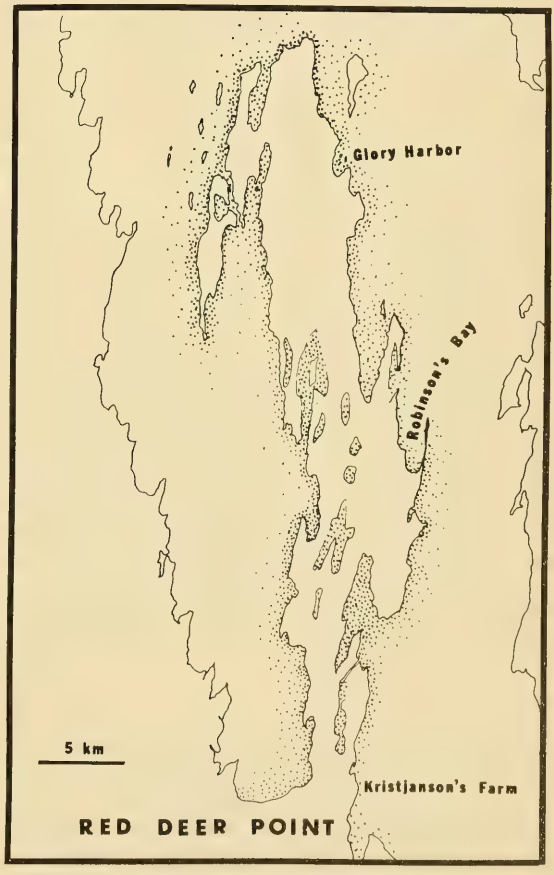

FIGURE 2. Red Deer Point, showing the three sampling sites.

tained taller aspens, a more closed canopy, and an open, grazed understory dominated by hazel (*Corylus* sp.). The physical environment varied more among the sites at Kristjanson's Farm than among the Glory Harbor sites, being on the average a bit drier and brighter. The site at Robinson's Bay was intermediate in structure and physical environment between the other two locations. Its ungrazed understory of *Aralia* and *Corylus* was quite dense. The point of sampling at various sites at each location was to get a qualitative feeling for the differences among sites at one location on the peninsula for comparison to the variation between locations. If the former overshadows the latter, then an apparent peninsular effect could merely reflect random variation among sites.

We captured small mammals with both Museum Special snap traps and Sherman live traps. Specimens were deposited in the collection of the Bell Museum of Natural History, the University of Minnesota. Ground beetles and shrews were captured in pitfall traps containing a small quantity of propylene glycol.

The sampling scheme requires explanation. In the absence of knowledge of the local fauna, the appropriate procedure in a study of this sort would be to sample equally intensively at the base of the peninsula and at the tip. We followed this procedure with pitfall trapping for carabid beetles. When the local fauna is known, however, equal sampling is not the best procedure. One's goal becomes the demonstration of the absence of known species from the tip. This is a difficult task to achieve by the sampling of a community of species of unknown population size. We had some information on the small mammal fauna based upon a pilot trapping project in September 1974. The sampling effort then although small (318 trap nights with Sherman live traps and 72 pitfall trap nights) yielded the following species: *Peromyscus maniculatus* (Deer Mice), *Clethrionomys gapperi* (Southern Red-Backed Voles), *Microtus pennsylvanicus* (Meadow Voles), *Zapus hudsonius* (Meadow Jumping Mice), *Sorex cinereus* (Masked Shrews), and *Microsorex hoyi* (Pygmy Shrews). This collection contained almost all the small mammals one could expect to capture in Sherman and pitfall traps in meadows and aspen woods of this part of Manitoba (Hall and Kelson 1959) with the exception of several uncommon shrews.

Given this information, we devised a sampling scheme for small mammals in which pitfall trapping for the relatively unknown shrew community would be equally intense at Glory Harbor and Kristjanson's Farm. We trapped, with Sherman live traps and snap traps, at Glory Harbor as intensively as possible, and at Kristjanson's Farm only until all the species known to be present were caught.

Results

In Table 1 the small mammals are listed. The most interesting feature of these data is the absence of *Clethrionomys gapperi* and *Sorex monticolus* (Dusky Shrews), at Glory Harbor. *Clethrionomys*, an easily trapped woodland vole, was about as common at the other two locations as *Peromyscus maniculatus*. *Sorex monticolus*, although not common, occurred at both Kristjanson's Farm and Robinson's Bay.

The other differences among sites do not merit serious consideration. The taking of one chipmunk, *Eutamias minimus*, reflects only the setting of a few traps near a stand of hardwoods on a levee at Glory Harbor. We set no traps in meadows at Robinson's Bay and, as expected, caught neither of the two meadow mice, *Microtus pennsylvanicus* and *Zapus hudsonius*, there.

The one obvious feature of the ground beetle collections (Table 2) was that Glory Harbor had nearly as many species as Kristjanson's Farm. What difference does exist pales by comparison to the variability between the two sites within each of the two locations.

The Carabidae, a diverse group, are noted for their affinity for particular physical microclimates. The lack of vegetational identity among the three sites leads to concern over possible bias toward or against a peninsular effect. We do not think this a cause for concern for several reasons. The vegetation is a highly variable mosaic at its most uniform and probably provides suitable habitat for any species living in aspen woods at any point along the length of the peninsula; moreover, we are not certain if the habitat differences we perceive are meaningful to carabid beetles living in the leaf litter. Of the 17 species at Kristjanson's Farm and 15 at Glory Harbor, 9 were held in comon, including 6 of the 8 most abundant species. Of the remaining 14 species not held in common, 8 are

TABLE 1—Comparison of small rodents and insectivores captured at three sites on Red Deer Point, Lake Winnipegosis, Manitoba, in June and July of 1975

	Kristjanson's Farm	Robinson's Bay	Glory Harbor
Sorex cinereus	1	9	16
monticolus	2	1	
Microsorex hoyi	3	19	7
Peromyscus maniculatus	2	11	4
Clethrionomys gapperi	3	8	
Microtus pennsylvanicus	9		11
Eutamias minimus			1
Zapus hudsonius	1		3
Total species	7	5	6
Trap nights	700	101	1200

TABLE 2—Comparison of carabid beetle fauna of Red Deer Point in June and July of 1975

Species	Kristjanson's Farm Site I	Kristjanson's Farm Site II	Robinson's Bay	Glory Harbor Site I	Glory Harbor Site II
*Agonum cupreum**		1			
decentis	1	2		3	21
gratiosum	1			1	
trigeminum				1	
(complex)	20		9	2	6
Amara cupreolata		1			
Badister obtusus	2		3	1	1
Bembidion (a)	3	1			1
Bembidion (b)				1	
Bembidion (c)	1				
*Calathus ingratus**	103	3	29	6	12
Calosoma frigidum	18	2		1	1
*Carabus maeander**				3	12
Chlaenius pensylvanicus	1				
*Cymindis cribricollis**	2				
Harpalus fulvilabrus	5				
pleuriticus				1	
Loricera pilicornis				1	
Metabletus americanus	2				
*Notiophilus semistriatus**			1		
*Patrobus foveocollis**				1	2
*Pterostichus adstrictus**	31	8	1	9	13
*Sphaeroderus lecontei**	7	1	3	1	2
*Synuchus impunctatus**	26	1	21		
Total numbers	223	20	67	32	71
Total species	15	9	7	14	10
Species per location	17			15	
Total trap days	400	150	225	180	338

*These species have poorly developed or vestigial wings.

represented by only one specimen. Therefore, of the original 23 species occurring either at Kristjanson's Farm or Glory Harbor, only 6 significant members of either community could be considered potential habitat specialists.

The choice to collect ground beetles arose from our impression that as a group they would be most likely to meet Simpson's assumption that colonization of empty habitats is more difficult near the tips of peninsulas. As a group, carabid beetles are not known as good dispersers, although the family is quite variable in this respect. *Calosoma frigidum* has large wings and flies well; it could probably disperse directly to the tip of Red Deer Point across the lake. By contrast, *Sphaeroderus lecontei* with no wings and fused elytra must walk wherever it goes. The species designated by asterisks in Table 2 are those that in our collections had either vestigial or only poorly developed wings. Some carabid species are dimorphic with respect to the presence of wings, but we found no winged morphs in our collections of these species. This is a conservative list of poor dispersers because some species with wings, such as *Amara cupreolata*, are not caught in light traps and probably cannot fly (Lindroth 1968). Even within this group we think it noteworthy that Kristjanson's Farm with six species and Glory Harbor with five had just about the same number. The proportion of the species assumed capable of flight is 53% at Glory Harbor (8 of 15) and 53% at Kristjanson's Farm (9 of 17). One would expect the flying species to comprise a greater percentage of the fauna at Glory Harbor if there were a peninsular effect.

Discussion

One could argue that one year's sampling effort is inadequate to support or refute the proposed peninsular effect. This would certainly be true if the hypothesized pattern were weak and fluctuating. If strong and stable, however, it should be revealed with one sampling effort. Under this assumption, we conclude that the carabid beetle community offers little support for

a peninsular effect, inasmuch as the differences between sites at one location on the peninsula exceed the differences among locations.

The only data for which we find no reasonable alternative explanation is the absence from the tip of *Clethrionomys*. Voles fluctuate dramatically, and one could argue that *Clethrionomys* is merely at a population low point at Glory Harbor. Although not an unreasonable argument, this requires that populations separated at most by 17 km fluctuate out of phase. We suggest that this itself would be evidence of a limitation of dispersal through no other mechanism than peninsular geometry.

Reserving judgment on *Clethrionomys,* we conclude that Red Deer Point does not exhibit an identifiable peninsular effect in either the small mammal or ground beetle communities. Inasmuch as Taylor and Regal (1978) have shown that the peninsular effect is logically possible, we can surmise only that the conditions for its unambiguous demonstration were not met at this site.

Rates of extinction are extraordinarily difficult to measure; any comments regarding them that we might make would be mere speculation. Rates of dispersal are more approachable, inasmuch as they are intimately linked with the morphologies and habits of the dispersing species. The possibility of overwater dispersal for small mammals in Lake Winnipegosis is minimal, although some species might be expected to disperse the length of Red Deer Point over land in as few as 3 or 4 yr. The point may be too small relative to the dispersal powers of mammals to allow extinctions to play an important role in determining distributions. *Clethrionomys* may be the exception to this.

The distributions of carabid beetles require different explanations. The species known to be capable of flight might colonize the peninsula quite rapidly over land or might be blown across the 5–8 km of water separating the peninsula from the mainland; the remaining species must either walk or drift on floating debris. Dispersal rates for several carabid beetles have been measured by den Boer (1971), as the length of time required to catch one beetle 100 m from the population using a standard set of pitfall traps. For *Calathus erratus*, a ground beetle of average size (8–11 mm), approximately 6 mo was required to trap one individual 100 m from the population. The first individual of *Carabus problematicus*, one of the largest ground beetles (21–28 mm), was trapped in 2–3 mo. Although these are conservatively high estimates for both species, they do provide a general idea of the dispersal power of flightless carabid beetles over land. If we assume that each generation can expand its range 100 m, the fact that these beetles are univoltine means that complete colonization of Red Deer Point would take about four centuries. This would seem to be ample time for the extinction of local populations to plan an important role. The absence of a peninsular decrease among the flightless species points to overwater colonization as an important factor.

Some recent theoretical work (Taylor, unpublished material) extends the original model of Taylor and Regal to include different orientations of peninsulas to the surrounding mainland. An unsurprising conclusion of that work is that of all possible orientations, a peninsula close to the mainland on both sides is least likely to show a decrease in species diversity near the tip in taxa capable of overwater dispersal.

We suggest, in conclusion, that the conditions for expression of a peninsular effect must be quite strict and that this is one biogeographic pattern that is likely to be rare.

Acknowledgments

We thank H. Kulman for advice and assistance and R. Armstrong and S. Taylor for help in the field. We are grateful in particular for the hospitality of Mr. and Mrs. T. Kristjanson, R. Kristjanson, and A. Kristjanson, without whose generosity the work would have been impossible to complete. Financial support was provided by the Graduate School of the University of Minnesota.

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Received 21 June 1980
Accepted 5 October 1980

Population Characteristics and Movements of Striped Skunks *(Mephitis mephitis)* in Central Alberta

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Bjorge, Ronald R., John R. Gunson, and William M. Samuel. 1981. Population characteristics and movements of Striped Skunks (*Mephitis mephitis*) in central Alberta. Canadian Field-Naturalist 95(2): 149–155.

Population characteristics and movements of Striped Skunks (*Mephitis mephitis*) were studied on a 130-km² area in central Alberta during 1971–1974. Estimates of a minimum density were amongst the lowest recorded; 0.7–1.2/km². Following the long winter of 1973–1974, numbers of young in natal dens and numbers of skunks on the study area were less than in 1973. Sex ratio of neonates was 1:1 but that of adults favored females. Adult male skunks moved greater distances than adult females; independent juveniles moved greater distances than adults. Dispersal was greatest during July and August when juveniles were about 3 mo of age; maximum dispersal was 22 km. The extensive dispersal of juvenile skunks, and lowered litter size and reduced density following a severe winter have not been reported from more southerly populations.

Key Words: Striped Skunk, *Mephitis mephitis*; population dynamics, movements, dispersal.

The Striped Skunk (*Mephitis mephitis*), common throughout much of North America (Hall and Kelson 1959), is of considerable public and animal health significance, particularly as a vector of rabies and leptospirosis (Ferris and Andrews 1966; Sikes 1970; Parker 1975). Studies of wild populations, including population characteristics and movements, have been limited to the eastern and central United States (Allen 1939; Allen and Shapton 1942; Verts 1967; Upham 1967; Houseknecht 1971; Bailey 1971; Storm 1972). The purpose of this paper is to summarize population trends, reproduction, sex and age ratios, and movements of adults and juveniles in a population of Striped Skunks in central Alberta, near the northern limit of agriculture, and to compare them with skunks of more southerly areas.

Study Area

The 130-km² Tofield study area (approximately 53°21′N, 112°43′W) was gridded by gravel roads every 1.6 km N/S and every 3.2 km E/W. The area is typical of agriculturally modified Trembling Aspen (*Populus tremuloides*) parkland which covers much of eastcentral Alberta (Bird and Bird 1967). The area contained eight aspen stands ranging in size from 30 to 65 ha, and many smaller patches of trees and shrubs in low or hilly areas, along fences, roads, and in farmyards. Most farms were about 200 ha; raising of cereal and forage crops and livestock predominated. Of 112 farmyards, 72 were occupied by humans while 40 were abandoned.

The climate is continental; characterized by warm summers and cold winters (Government of Alberta and University of Alberta 1969). The mean temperature from May through September is 13° C and from November through March -9° C. The frost-free period is about 100 d and the mean annual precipitation is 45 cm with 30% falling as snow. Landscape is undulating to gently rolling (0–9% slope) and natural drainage is good (Bowser et al. 1973).

Methods

The study was carried out during 1971 through 1974 in conjunction with studies of skunk rabies in eastern Alberta and Saskatchewan (Gunson et al. 1978). Skunks were captured by livetrapping (wooden and metal box traps), night-lighting, and excavation of dens. During April through October, 50 to 60 live traps were placed throughout the study area at locations ~ 800 m apart and subjectively determined to be good areas to trap skunks. Such locations commonly included fence rows, abandoned buildings, woodlot fringes, and culverts. Traps were checked daily and baited about once per week, usually with chicken entrails. Skunks were detected during night-lighting from a pickup truck equipped with two aircraft landing lights. These skunks were pursued on foot, netted, and handled similarly to live-trapped skunks.

Skunks were captured or counted at natal dens located beneath buildings by removing floor boards or digging under the foundation during June and July. Young skunks were returned to the den within 1 h. Buildings and diggings were restored before skunks were returned. In December 1974, at the end of the study, skunks were gassed with carbon monoxide while in winter dens under buildings. Uteri were removed and prepared for counts of placental scars (Orsini 1962).

Skunks were handled as described by Jacobson et al. (1970). Each ear was tagged with numbered finger-

ling metal tags. Fourteen skunks, including nine adult females and five juveniles were equipped with radio collars. Transmitters were similar to those utilized by Brand et al. (1975) and constructed by the Department of Electrical Engineering, University of Alberta. Locations were determined by triangulation with a loop antenna and a portable receiving unit. Most telemetry locations were determined during daytime when skunks were resting.

Juveniles were distinguished from adults by body weight, size, and general appearance. As juveniles were similar in appearance to adults after October, and most were captured in natal dens during May through July, only skunks captured during August through October were used in calculating age ratios.

Estimates of annual variation in numbers were derived from livetrapping success during August and September because comparable data were available from all years of the study only during these months; in 1971 trapping began in late July and in 1972 trapping was conducted only in spring and fall.

Greatest distance between the most extreme captures during a specified period (Brant 1972; Sanderson 1966; Bailey 1971) was utilized as an index of home range and dispersal. Because of the relatively wide spacing of traps, some greater movements likely were not recorded. Information derived from telemetry was utilized to calculate home ranges (Mohr 1947) and minimum daily movements.

Weather records were taken from Environment Canada, Annual Meteorological Summaries 1970–1974. Temperature records were from Camrose, Alberta, about 30 km south of the study area. Precipitation records were available only from Edmonton, Alberta, about 70 km to the west.

Results and Discussion

Reproduction

During 1973 and 1974, 42 of 48 (88%) adult females were either lactating or had suckled young (32 of 35 in 1973, 10 of 13 in 1974). Such high pregnancy rates have been noted elsewhere; Verts (1967) found 72 of 75 (96%) females in Illinois were pregnant, while Gunson and Schowalter (unpublished data) observed that 99 of 112 (88%) females from eastern Alberta and Saskatchewan were pregnant or had given birth to young.

Mean litter size ± SE (counts of young in natal dens) was larger in 1973 (5.2 ± 0.8 of nine litters) than in 1974 (2.5 ± 0.4 of six litters) (t-test, $P < 0.05$). Litter sizes of wild skunks, including embryos, neonates, and placental scars, range from 5.8 to 7.3 (Allan 1939; Hamilton 1963; Verts 1967; Bailey 1971; Gunson and Schowalter, unpublished data), suggesting our 1974 skunk litters were considerably smaller than those reported elsewhere.

Difference in litter size between 1973 and 1974 was likely related to snowfall and temperature during winter denning (Table 1). Snowfall was about 1.7 times greater during winter 1973–1974, with more snow falling earlier and staying longer. Temperatures were also lower during November 1973 and March 1974, usually the first and last months of winter denning (Gunson and Bjorge 1979), than 1 year earlier. Analysis of age data, as follows, suggested that reproduction and/or survival of juveniles was low following the relatively heavy snowfall and long winter of 1970–1971, as well. Of the skunks captured during August through October, 18 of 37 (49%) were juveniles in 1971 compared to 23 of 33 (70%) in 1972, 52 of 75 (69%) in 1973, and 35 of 60 (58%) in 1974.

In northern parts of their geographic range, such as Alberta, Striped Skunks spend more time within the winter den during long winters than short winters (Gunson and Bjorge 1979). As they do not feed during winter denning at northern latitudes (Mutch and Aleksiuk 1977), their body condition would likely be poorer after long, cold winters. Skunks in Minnesota lost a mean of 49% body weight during winter 1968 followed by significantly greater mean losses of 58%

TABLE 1—Weather records during winter denning, parturition (May), and lactation (May–June) of Striped Skunks at Tofield, Alberta[a]

Variable	Month	1970–71	1971–72	1972–73	1973–74
Snowfall (cm)	October–April	100	167	130	219
Snow on ground (cm)	30 November	25	3	5	20
	31 March	56	10	0	74
Rainfall (cm)	April–June	20	17	32	16
Mean monthly temperature (°C)	November	−9.3	−14.5	−3.8	−14.1
	December	−17.6	−16.8	−15.8	−12.9
	January	−18.9	−19.3	−12.5	−15.3
	February	−9.6	−16.0	−10.1	−11.1
	March	−7.8	−6.1	−3.1	−12.1

[a]Most important are the snow on ground 30 November and 31 March and temperatures during November and March.

during the longer winter of 1969 (Sunquist 1974). Breeding occurs primarily during March (Wright 1931; Hamilton 1963; Bjorge 1977) near the end of winter denning. It follows that reproduction and survival of juveniles may be lowered as a result of a long winter. Lower reproduction and survival of young during periods of decreased food supply have been documented for several carnivores including Coyotes (*Canis latrans*) (Clark 1972) and Lynx (*Lynx canadensis*) (Brand et al. 1976).

Numbers of placental scars ± SE from 15 females with scars killed during December 1974 averaged 6.0 ± 0.5; 2.4 times as great as the mean number of young counted in dens that year. Previous studies documented resorption of embryos (Verts 1967) and death of small juveniles within a few days of birth (Rakowski 1972). Increased resorption of embryos and neonatal mortality after a long winter likely accounted for the small litters observed in 1974. As well, the cooler temperatures recorded during May 1974 could have hampered survival of neonates because natal dens of Striped Skunks are often in relatively exposed (granaries and other structures without foundations) sites in Alberta (Bjorge 1977). Heavy rainfall occurred during May and June 1973 when litters were largest, suggesting that rain during the first 2 mo after birth was not a negative factor.

Numbers, Age, and Sex

Livetrapping success during August and September increased from 1971 through 1973, and then decreased in 1974, suggesting two- to three-fold changes in population densities (Figure 1). Total numbers captured during May through October in 1974 (93) were lower (chi-square test, $P < 0.001$) than in 1973 (155) despite increases in trapping and night-lighting efforts in 1974 (4757 trap-nights versus 4082 in 1973; 448 km versus 121 km in 1973).

Marked fluctuations in numbers of Striped Skunks have been reported (Allan and Shapton 1972; Verts 1967). Verts (1967) summarized success of skunk trappers during 25 seasons in Illinois; twofold changes in trapper success during successive years likely reflected comparable changes in density. Allan and Shapton (1942) attributed population variations to "disease" while Verts (1967) provided no explanation. Tests for rabies virus and antibodies to leptospirosis, tularemia, and western equine encephalitis from 47 skunks collected at the termination of this study were negative (J. Iverson, Western College of Veterinary Medicine, Saskatoon, and D. Schowalter, Alberta Fish and Wildlife Division, Edmonton). It is unlikely that disease was a significant factor in population regulation of skunks in this study.

Decreased recruitment of young in 1974 was not entirely responsible for lowered populations that year.

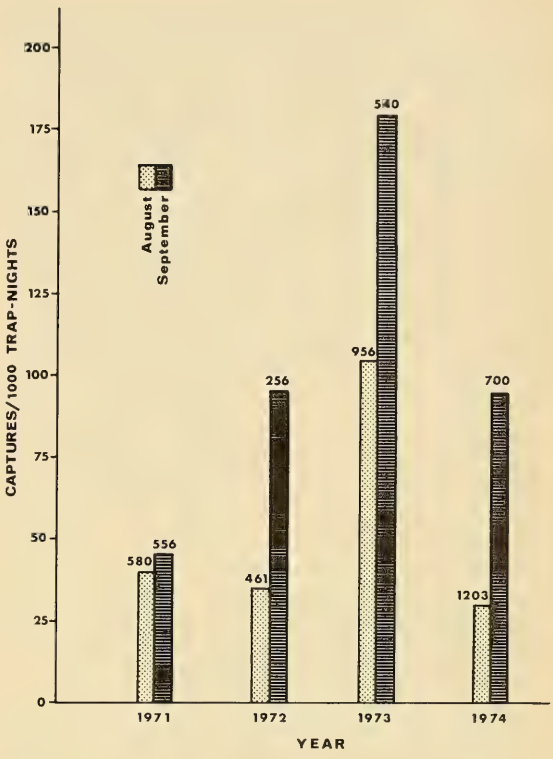

FIGURE 1. Success of Striped Skunk captures at Tofield, Alberta, during August and September, 1971 through 1974. Numerals indicate trap-nights.

Fewer adults were located in 1974 (37) than 1973 (51) despite greater capture efforts in 1974. Sunquist (1974) thought that winter-related mortality of skunks was important in Minnesota. Limited data from this study support that; we found 11 dead skunks under buildings following the severe winter compared to 3 following the mild winter.

Our observations of capture success, litter size, and age structures indicate that populations of Striped Skunks in northern areas are importantly influenced by severity of weather during the preceding winter, especially the length of winter. Numbers of skunks decrease following long winters and increase following short winters. Particularly important is accumulated snow during the first and last months of winter, usually November and March. In northern areas, winters likely have greater potential regulation of numbers of Striped Skunks. Densities of skunks in more southerly habitats with less rigorous winters are more apt to be regulated by other factors.

Minimum density estimates in our study, based on total captures for 1973 and 1974, were 1.2/km^2 and

0.7/km², respectively. Other estimates, also determined from total numbers of skunks captured within a given area, varied from 0.4–1.4/km² in Iowa (Scott and Selko 1939) to 11.5–27.0/km² in Illinois (Ferris and Andrews 1966). Additional estimates of density, determined from a variety of techniques, varied from 1.9–3.1/km² in North Dakota (Upham 1967) to 4.4–4.6/km² in Ohio (Bailey 1971).

The sex ratio of captured adults was significantly unbalanced in favor of females (chi-square test, $P < 0.01$) (Table 2). This pattern was comparable in both adult skunks captured by livetrapping (36% males of 120) and night-lighting (35% males of 23). When sex ratios for all years were combined by month, more females than males were captured in all months except April when 7 of 13 skunks were males. All evidence indicated that more adult females than males were present as reported elsewhere (Bailey 1971; Storm 1972). Verts (1967) observed a change from a ratio favoring males during the first 3 yr to one favoring females during the last 2 yr of his 5-yr study. Most collections or captures of skunks during winter and early spring (Bennitt and Nagel 1937; Hamilton 1937; Casey and Webster 1975) have favored males, likely because males are more active than females during cold months (Gunson and Bjorge 1979).

The apparent change in sex ratio from one favoring males among juveniles (Table 2) to one favoring females among adults suggests a greater mortality rate for adult males. Adult males are intolerant of each other (Allan and Shapton 1942), more active during cold months, often den alone during winter, may compete with other males for aggregations of females (Gunson and Bjorge 1979), and travel extensively in early spring during mating (Allan and Shapton 1942; Ferris and Andrews 1966). Males are probably subject to higher mortality from accidents, fighting, predation, and human causes, because of the above factors.

The sex ratio of juveniles after leaving the natal den favored males [84 of 138 (61%)] (chi-square test, $P < 0.01$) (Table 2). That of neonates in dens also favored males [35 of 62 (56%)], but the difference was not significant; a finding not uncommon for neonates and embryos of wild skunks (Hamilton 1963; Verts 1967). Monthly sex ratios of independent juveniles (all 4 years combined) varied from 67 to 69% males during July, August, and September, but dropped to 53% males during October. Possible reasons for this change would include differential trapability, mortality, or dispersal.

Previous studies indicate varying sex ratios among independent juveniles. Verts (1967) and Storm (1972) documented 44 and 45% males among 84 and 42 livetrapped juveniles in Illinois. In Saskatchewan and eastern Alberta, Gunson and Schowalter (unpublished data) found 56% of 364 juveniles were males.

TABLE 2—Percentage (*N*) male Striped Skunks captured at Tofield, Alberta, during April through October, 1971–74.

Year	% males (*N*)	
	Adults	Juveniles[a]
1971	37(19)	61(18)
1972	48(33)	65(23)
1973	29(51)	54(56)
1974	38(37)	68(41)
Mean	37(140)	61(138)

[a]Includes juveniles captured July through October (excludes juveniles captured in natal dens).

Movements of Adult Skunks

Comparison of greatest linear distance between captures of adult skunks indicated larger home ranges for males than females (Table 3). Upham (1967) and Storm (1972) also recorded more extensive movements for adult male than adult female Striped Skunks in North Dakota and Illinois, respectively, but Houseknecht (1971) observed the opposite in Minnesota.

TABLE 3—Mean ± SE greatest linear distance and ranges between captures of Striped Skunks at Tofield, Alberta, during May through October, 1973 and 1974

Cohort	Number of skunks	Mean distance (m)	Range[a] (m)
Adult males	17	2556 ± 231	1200–4 050
Adult females	30	1970 ± 170	700–4 200
Total	47	2197 ± 143	700–4 200
Juvenile males	29	3310 ± 410	850–10 100
Juvenile females	19	4150 ± 1191	650–21 700
Total	48	364o ± 640	650–21 700

[a]Measured to the nearest 50 m.

Seasonal variation in home range, as indexed by greatest linear distance between captures, was obvious. In general adult females were most sedentary during parturition and lactation (May and June), and travelled more following weaning (July and August) and less during predenning (September and October) (Table 4). Adult males moved increasingly greater distances from May and June through September and October. Greater movement of adult males during fall was also reported by Storm (1972). During winter, communes of females generally den with one male, usually an adult (Gunson and Bjorge 1979). Adult males appear to search for groups of females during fall (Gunson and Bjorge 1979), leading to greater mobility during that period.

TABLE 4—Mean ± SE (*N*) greatest distance movements (m) of adult Striped Skunks between capture at Tofield, Alberta, during 2-mo periods between 1 May and 31 October, 1973 and 1974

Cohort	May–June	July–August	September–October
Adult male	1782±234(4)	2108±462(11)	2849±369(8)
Adult female	510±214(11)	2207±331(12)	1260±269(8)

Mean home range calculated according to Mohr (1947) for six adult females radiotracked for 45–105 d (mean of 44 fixes, range 20–62) was 208 ha (range 110–370 ha). Storm (1972) reported mean home ranges of five adult females that were radiotracked for more than 15 d during summer at 362 ha.

Minimum daily movement (distance between dens used on consecutive days) for five radio-collared adult females using 41 dens was 1.5 km (range 0.1–2.8 km). One adult female was extremely mobile, moving a mean of 2.3 km between dens during 8 d; however, all these movements were within one home range of 370 ha. The greatest distance between daily locations for this skunk during 97 d of radiotracking (51 fixes) was 3.7 km. This suggests that adult skunks are capable of moving over a large portion of their range within a day or so.

Movements of Juveniles

Juvenile skunks moved significantly greater distances (*t*-test, $P < 0.05$) between captures than adults (Table 3). At least 4 of 62 juveniles marked in natal dens during June 1973 and 1974 dispersed, moving a mean distance of 11.1 km (dispersal is defined as any straight-line movement greater than 4.8 km, because no adults moved more than this distance). Of the four juveniles, only one was captured on the study area beyond August, despite intensive livetrapping and night-lighting during 1973 and 1974 and excavation of winter dens in December 1974. This skunk, a male, was present on the study area about 8 km from his natal den, during September of the year following marking. Of 196 juveniles captured (including those captured in natal dens), 148 were caught only once. Of the 48 recaptures, 11 (23%) had dispersed (Table 5).

These data suggest that most juveniles born on the study area during 1973 and 1974 dispersed. Occasional observations at six natal dens following excavation indicated that families of skunks usually did not vacate the den after marking. Death resulting from capturing and marking neonates was not considered a significant mortality factor. Survival of juveniles after marking was demonstrated at 7 of 15 dens while no data were available from the other dens. Maximum recorded distance of dispersal was 22 km. Dispersing juveniles travelled relatively great distances within a short time; a radio-instrumented male travelled 8.0 km within 6 d, a juvenile male moved 5.8 km within 2 d, and a juvenile female moved 3.7 km in 1 d.

Most dispersal occurred between weaning in early July (Bjorge 1977) and 1 September. Recapture rates of juveniles first captured in natal dens during June and July were lower than recapture rates of adults captured during the same period (chi-square test, June, $P < 0.005$; July, $P < 0.05$) (Table 6). Juveniles

TABLE 5—Sex, dates, and distances of dispersing juvenile Striped Skunks at Tofield, Alberta, during 1973 and 1974. Includes all skunks known to have travelled straight-line distance ¼ 4.8 km

Date of first and last capture	Distance[a] (km)
Males	
7 July — 17 August	10.1
26 June — 29 August	8.4
21 August — 28 August	8.1
24 July — 14 August	5.2
1 August — 21 August	4.8
15 August — 27 August	5.1
28 August — 30 August	5.9
Females	
4 July — 31 August	21.7
17 July — 30 November	13.7
1 October — 30 October	5.8
1 September — 22 October	5.6

[a]Measured the nearest 50 m.

TABLE 6—Occurrence of recapture and mean number of days (± SE) between first and last capture during the same year for adult and juvenile Striped Skunks captured at Tofield, Alberta, between May and October, 1973 and 1974.

Month	Age	*N*	Recapture (%)	Time (d)
May	Adult	16	81	76±16
June	Adult	21	62	88±31
	Juvenile[a]	62	8	91±16
July	Adult	18	61	71±16
	Juvenile	17	24	19± 4
August	Adult	13	69	60±14
	Juvenile	31	48	36± 8
September	Adult	12	75	46±13
	Juvenile	31	52	44± 7
October	Adult	5	100	44±13
	Juvenile	17	47	29± 6

[a]Includes juveniles captured in natal dens.

captured during July and August were known to be alive on the study area for fewer days (based on days between first and last capture) than adults captured during these months (July, $P < 0.005$; August, $P < 0.05$). The known periods of dispersal (Table 5) and the high rate of disappearance of marked juveniles from the study area indicate that dispersal was greatest when juveniles were 3 to 4 mo of age.

Juvenile skunks in Illinois, monitored during late summer and fall by telemetry and livetrapping, moved up to 2.2 km (Verts 1967). Storm (1972) concluded that the home ranges of radio-marked juveniles in Illinois were smaller than those of adults, and Bailey (1971), in Ohio, determined that the average straight-line distance between live captures was less for juveniles than adults. The most extensive movement of a juvenile in his study was 2.1 km over 27 d. Upham (1967) noted that juveniles in his study in North Dakota moved only slightly greater mean distances than adults; one juvenile travelled nearly 9 km.

These observations suggest that juvenile skunks in Alberta disperse greater distances than those in more southerly areas. Gunson and Bjorge (1979) suggested that the observed mobility of juveniles, particularly females, could be related to a search for a suitable and available winter den. Although female skunks in central Alberta den in winter communes, juvenile females may be excluded from some dens (Gunson and Bjorge 1979). Winter dens are likely more widely dispersed in central Alberta than in more southerly areas. Extensive dispersal of juveniles is of major significance to management of diseases transmitted by skunks. The potential for spread of disease by highly mobile juvenile skunks is recognized.

Acknowledgments

This study was supported by the Veterinary Services Division, Alberta Agriculture, the Fish and Wildlife Division, Alberta Energy and Natural Resources, the National Research Council of Canada (operating grant A-6603 to WMS), and the University of Alberta. The interest and support of H. Vance of the Veterinary Services Division is gratefully acknowledged. P. Andersen, E. Ewaschuk, W. Johnson, L. Pecharsky, D. Pipella, and W. Wynnyk capably assisted in the field. D. Schowalter and L. B. Keith reviewed drafts of this paper.

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Received 25 March 1980
Accepted 6 October 1980

Natural History of the Ebony Spleenwort, *Asplenium platyneuron* (Aspleniaceae), in the Great Lakes Area

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Wagner, Warren H., Jr., and David M. Johnson. 1981. Natural history of the Ebony Spleenwort, *Asplenium platyneuron* (Aspleniaceae), in the Great Lakes area. Canadian Field-Naturalist 95(2): 156–166.

Once very rare in the Great Lakes region, the Ebony Spleenwort, *Asplenium platyneuron*, appears to be spreading rapidly in many localities where it was previously unknown. The species had been either very sporadic or absent in this region. The major habitats are dry forest and forest edges, shaded steep road banks, pine plantations, and second-growth old fields, pastures, and orchards. The fronds average 14–16 per plant, the number of low, short, sterile leaves usually twice as many as upright, tall, fertile leaves. Much of the starch storage occurs in the thickened petiole bases which may be retained for a number of years after the rest of the frond has died. Vegetative proliferation by tiny plantlets produced on the lowest pinnae takes place in about 1 of 20 plants growing in dry upland sites and 1 of 5 in moist lowland sites. Variations with strongly incised pinnae are rare, but in at least one population 1 of 8 plants showed this condition. Intermediates between incised and nonincised forms are also found. We hypothesize that the invasive success of *A. platyneuron* is due to its ability to grow terrestrially in competition with other plants, its tall sporophylls, the capacity of storing considerable starch in the petiole bases, and the ability to propagate vegetatively under certain conditions. Factors such as increased area of second-growth habitats and warming climatic conditions may have also played a role. We believe that none of the so-called "varieties" of this species merit that taxonomic designation; they should be treated instead as mere trivial forms without special nomenclature.

Key Words: Ebony Spleenwort, *Asplenium platyneuron*; range expansion, leaf dimorphy, starch storage, vegetative proliferation, incised variations, taxonomy.

Ebony Spleenwort, *Asplenium platyneuron*, is unusual among temperate North American spleenworts in being terrestrial as well as saxicolous. The species occurs from Quebec and Ontario south to Florida and Arizona, becoming rare and sporadic near the periphery of its range. In the Great Lakes region it was considered a very rare fern until the 1960s (Billington 1952), but during the past 20 years it has been invading this region, spreading rapidly and forming large populations.

Throughout its range the species is highly variable, and six infraspecific taxa have been recognized, five of which have been found to occur in the Great Lakes area. The biological significance of these taxa has not been studied adequately, and the purpose of this study was to elucidate the factors allowing Ebony Spleenwort to increase its range, and to determine the nature and extent of this variability.

Materials and Methods

To assess the expanding patterns in the range of *A. platyneuron*, we used our field observations in Michigan, published reports, data from herbarium specimens, and information provided by various individuals for Michigan and elsewhere. We recorded plant species growing within several metres of spleenwort plants in a number of habitats in Michigan. We also studied frond structure and variation by collecting random samples of plants from large populations, some of which were cleared in 5% aqueous NaOH, stained with safranin, and drawn under a microprojector for examination of pinna and venation variation. We examined foliar storage organs using hand sections and the iodine test for starch.

Distribution of Ebony Spleenwort

A northward range expansion has taken place in the past 20 years (see Figure 1 where the dots represent older records and the stars more recent ones). This trend is supported by statements from numerous field workers based on their experiences over the last two decades. In Kalamazoo County, Michigan, the species was once unknown (Hanes and Hanes 1947), but Harvey Ballard of Western Michigan University (personal communication 1979) informed us that now "It appears to be an aggressive and 'weedy' species, common in many places in the county." Thomas Carlson of The University of Michigan (personal communication 1979) wrote that in the Three Rivers Game Reserve in St. Joseph County, Michigan, "the original ten populations (in 1971) have now expanded, while many new ones have become established, particularly on disturbed ground along roads, trails, and corn fields, and in pine stands." In Ontario, A. A. Reznicek of The University of Michigan (personal communication 1980) reported that this species, once confined to the Kingston and Georgian Bay areas, "has undergone a tremendous explosion in the past decade . . . The

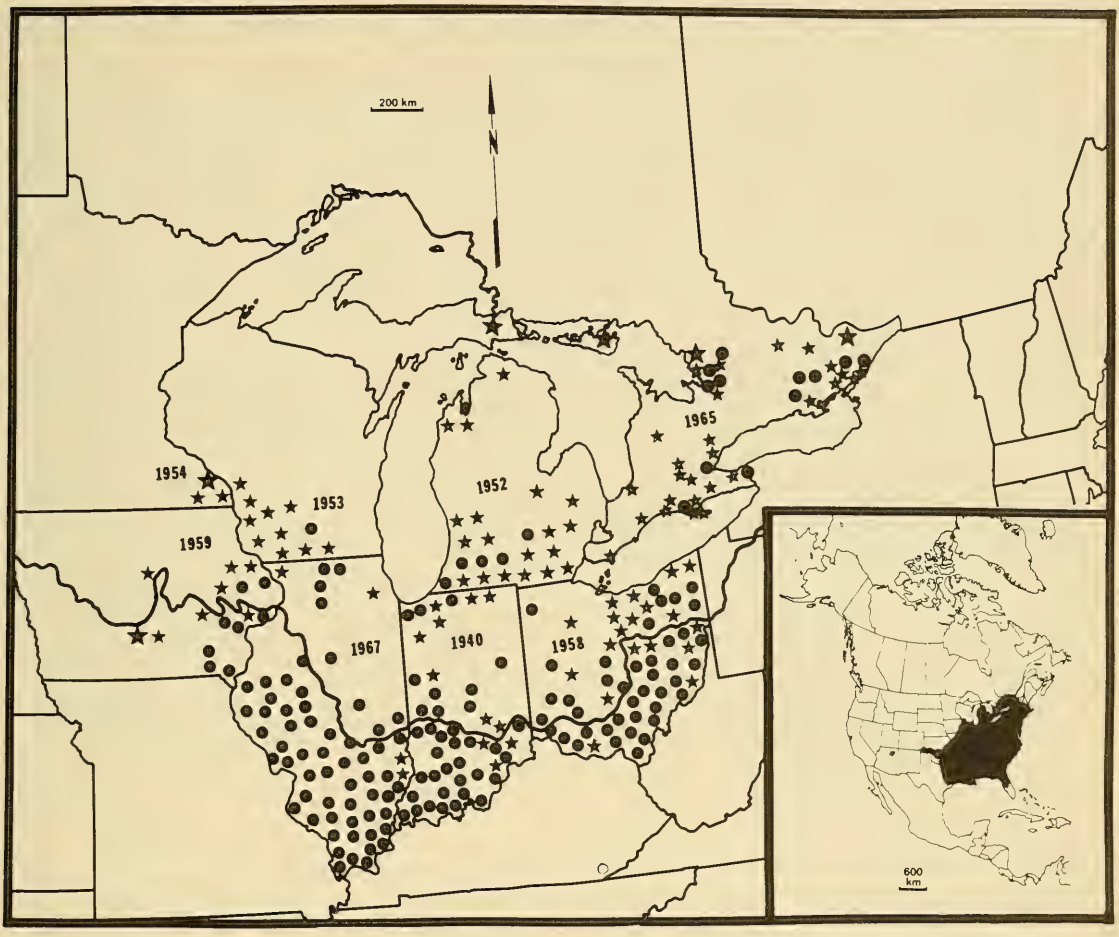

FIGURE 1. The distribution of Ebony Spleenwort in the Great Lakes region. Dots represent records from the following sources: Illinois, Mohlenbrock (1967); Indiana, Deam (1940); Iowa, Cooperrider (1959); Michigan, Billington (1952); Minnesota, Tryon (1954); Ohio, Adams (1958); Ontario before 1965, A. A. Reznicek (personal communication 1980); and Wisconsin, Tryon et al. (1953). Stars indicate records since these respective dates supplied by individuals (see Acknowledgments), who examined specimens in herbaria in the state or province with which they are identified. Large stars serve to emphasize peripheral stations, and the irregular line through Iowa, Indiana, Illinois, Ohio, Pennsylvania, and New York represents the glacial boundary. The inset shows the entire range of the Ebony Spleenwort.

plant can now barely be considered rare in Ontario." Charles Sheviak of New York State Museum, Albany, (personal communication 1980) considered *A. platyneuron* "now a common plant throughout Illinois," where Pepoon (1927) called it "the rarest of our ferns" in the Chicago region.

The best documented instance of increase in individual population size was provided by the work of Arthur J. Cooper of North Carolina State University, who found and mapped the localities of six plants at five sites in a 1958 study at The University of Michigan's Edwin S. George Reserve in Livingston County, Michigan. He was impressed that he never found more than one plant (except for two plants at one locality) at any one place, and therefore collected no vouchers to avoid eradicating any of the populations. He provided us, however, with a minutely detailed map of the 1958 localities which enabled us to revisit each site in 1979 and find out what had happened to the five populations in the intervening 21 years. At four of the five sites where plants could still be located, the number of plants had increased from 6 to 34. In

addition, we found 122 plants at three additional sites within the Reserve, making it fairly common where in 1958 it had been rare and local.

The Ebony Spleenwort is clearly extending its range northward, being known now from Chippewa County in the Upper Peninsula of Michigan (Hagenah 1955), Manitoulin Island, Ontario (J. Morton, University of Waterloo, personal communication 1980), and from the vicinity of Ottawa (D. Britton, University of Guelph, personal communication 1980). Even considering the amount of field work that has been carried out by botanists in this region since 1950, this increase in range exceeds normal expectations. If this population explosion continues, new localities for this species should be discovered at the northern and western peripheries of its range where it was never before anticipated.

Most ferns of the genus *Asplenium* in temperate North America occur in crevices, on rocks, or on talus, and are unable to grow in competition with other vascular plants. In contrast, Ebony Spleenwort usually grows directly upon ground soil interspersed with many species of other vascular plants. In southern Michigan we have found it principally in dry forest and forest edges, on shaded steep road banks, in pine plantations, and in second-growth old fields, pastures, and orchards. These habitats are discussed below in order of increasing frequency of the ferns.

In all habitats, including the forest, growth of the spleenwort appears to be fostered by disturbance. In the forest this is provided by natural and artificial light gaps and clearings and by erosion on steep slopes. The typical forest occurrences are in dry upland woods of Red Maple (*Acer rubrum*), Serviceberry (*Amelanchier arborea*), Pignut Hickory (*Carya glabra*), Black Walnut (*Juglans nigra*), Black Cherry (*Prunus serotina*), White Oak (*Quercus alba*), Red Oak (*Q. rubra*), and Black Oak (*Q. velutina*) which have a well-developed oak litter, and associated shrubs including Black Huckleberry (*Gaylussacia baccata*), Fall Witchhazel (*Hamamelis virginiana*), Common Juniper (*Juniperus communis*), Prickly Gooseberry (*Ribes cynosbati*), and Black Raspberry (*Rubus occidentalis*). Ebony Spleenwort also occurs on steep road banks in such forested areas, often growing with Fragile Fern (*Cystopteris fragilis* var. *mackayii*).

Plantations of Scots Pine (*Pinus sylvestris*) or White Pine (*P. strobus*) in southern Michigan usually support small Ebony Spleenwort populations. Here the plants grow in the thick needle layer with other plantation adventives such as Manitoba Maple (*Acer negundo*), Tatar Honeysuckle (*Lonicera tatarica*), White Mulberry (*Morus alba*), Black Cherry, Prickly Gooseberry, Swamp Nightshade (*Solanum dulcamara*), Black Raspberry, and Red-berried Elder (*Sambucus pubens*).

Second-growth old fields, pastures, and orchards in later stages of succession (Figure 2) provide the most productive habitats for the Ebony Spleenwort, which in these sites may build up populations of thousands of individuals. The plants usually grow in the shade of scattered trees such as Red Maple, Black Walnut, Eastern Red Cedar (*Juniperus virginiana*), Trembling Aspen (*Populus tremuloides*), Black Cherry, Sassafras (*Sassafras albidum*), and White Elm (*Ulmus americana*), but occasionally appear in grassy areas in full sunlight. The plants are often concentrated in thickets of Gray Dogwood (*Cornus racemosa*), Common Juniper, or *Rubus* spp. Other associates in these habitats include saplings of Pignut Hickory, White Ash (*Fraxinus americana*), Scarlet Oak (*Quercus coccinea*), Red Oak, and Black Oak, the shrubs New Jersey Tea (*Ceanothus americanus*), Autumn Olive (*Elaeagnus umbellata*), Chokecherry (*Prunus virginiana*), Tatar Honeysuckle, and *Rosa* spp., and the vines Virginia Creeper (*Parthenocissus quinquefolia*) and Riverbank Grape (*Vitis riparia*). Many of the herb associates are of Eurasian origin. The clubmoss *Lycopodium digitatum* (formerly treated as *Lycopodium complanatum* var. *flabelliforme*) is also commonly present. Four species of grape ferns (*Botrychium*) are known to grow with the spleenworts, but they do not form weedy populations.

A number of observers have commented on the intrusive nature of the Ebony Spleenwort. In Ontario, A. A. Reznicek (personal communication) reported Ebony Spleenwort from rock outcrops, forested dunes, and beach ridges, and pointed out that "Ebony Spleenwort does not seem to care whether the rock is acidic or basic and a wide variety of sandy soils also seem suitable. It seems to be drought-tolerant and happy in both sun and shade." In Illinois Charles Sheviak (personal communication) attributed its dramatic increase in abundance to "the species colonization in old fields, abandoned pastures, and similar disturbed sites." The success of *A. platyneuron* in becoming an aggressive and weedy plant cannot be explained, however, entirely in terms of its colonization of successional habitats, as evidenced by the non-weedy nature of *Botrychium* species. Other characteristics which might preadapt it for making an invasion are best illustrated by comparing it with near relatives such as *A. montanum, A. resiliens, A. septentrionale,* and *A. trichomanes* which have never been reported to be aggressive invaders.

Morphology of Ebony Spleenwort

As background we expand here the descriptions of frond structure to include features not previously emphasized by other authors. The horizontal rhizome of the Ebony Spleenwort is very short so that the leaves are crowded together and the plants appear

FIGURE 2. The second-growth old field habitat of *Asplenium platyneuron* in southeastern Michigan.

tufted. The leaves reach two extremes in morphology — stiff, tall, erect, brittle, easily broken, fertile fronds which tend to die back in the fall, and pliable, spreading or prostrate, short, sterile fronds which persist through the winter — but a spectrum of intermediates occurs. Plants of dry upland habitats occasionally have fertile fronds which resemble the sterile ones. On a given plant the number of sterile leaves greatly exceeds the number of fertile and intermediate leaves; 20 upland plants from Lyndon Township, Washtenaw County, Michigan, gave an average of 16 (range 7–36) fronds per plant, of which 5 were fertile, 1 was intermediate, and 10 were sterile, and 20 lowland individuals from the same locality averaged 14 (range 6–34) fronds per plant, of which 4 were fertile, 1 intermediate, and 9 sterile.

Starch storage in petiole bases is a phenomenon which has not been described for this species and is probably more widespread in the ferns than is realized because it is best recognized in live plants and may not be evident unless sections are made. Herbarium specimens do not show the storage areas well because of the drying and collapse of tissues.

Most fertile fronds die in the Fall while the sterile fronds persist through the winter. All of the fronds appear to remain alive at their bases for several years (Figure 3). We discovered rhizomes estimated, from the number of frond bases present, to be 5–7 years old on which even most of the oldest frond bases were still alive and contained masses of storage parenchyma. The firm yellowish-white storage tissue contains numerous small starch grains and is protected by the dark occluded outer cortical and epidermal cells of the petiole base. The extent of the storage on a given petiole can be readily determined by pinching the petiole base. The storage region feels hard and thickened, while the dead petiolar area distal is dry and collapses easily. Many petioles that are several years old have disintegrated completely down to the point where the storage base terminates.

Food storage in *A. platyneuron* is substantially foliar rather than cauline (Figure 3), possibly partly as a result of the size of the dictyostele in the true stem. The sclerotized densely overlapping petiole bases probably also function in protecting the delicate rhizome and bud tissues. The tissues of the storage petiole

FIGURE 3. Starch storage in petiole bases of *Asplenium platyneuron*. Top left, longitudinal section of rhizome and petioles; top right, cross section through rhizome and petioles; lower left, lateral view of intact rhizome and petioles; lower right, ventral view of rhizome and petioles.

bases are also capable of dedifferentiation and growth — petiole bases on damp sphagnum or sand produced new plants.

In other fern genera with storage petiole bases, such as *Onoclea, Matteuccia, Athyrium,* and *Dryopteris,* there is a tendency toward abortion of the entire frond except for the storage base. This tendency reaches its best development in the Southern Fragile Fern (*Cystopteris protrusa*) which has cataphyll-like storage bases (Wagner et al. 1970). Other North American species of *Asplenium* have storage areas which are weakly or not developed.

The production of foliar buds is known in many fern families and genera and has been discussed by DeBenedictus (1969), who recognizes three types, all of which occur in the Aspleniaceae: (1) buds on leaf blades and margins, (2) axillary or rachis buds, and (3) leaf tip proliferations. Faden (1973) showed that rachis buds are most common among the gemmiferous spleenworts of tropical East Africa. The ability of the Ebony Spleenwort to form foliar proliferations has long been known, having been reported from plants cultivated in England in 1816 (Weatherby 1924). Plants exhibiting these proliferations were recognized taxonomically by Eaton (1879) as *Asplenium platyneuron* var. *proliferum*, later reduced to the status of form by Tanger (1933). Some writers have regarded the proliferation process as the result of abnormal conditions. Marshall (1923) reported finding that 25 out of 75 plants growing in a basement had buds, and then only on sterile fronds. Floyd (1924) believed that the proliferations were a form of reproduction which resulted when the plants were under stress.

In the populations of *A. platyneuron* we examined from the Great Lakes region, we found proliferous plants at practically every site. Most buds were buttonlike, pale-green, or whitish masses 1.0–1.5 mm in diameter on the adaxial side of the lowest pinna (Figure 4). Rarely there was also a bud on the second pinna. These buds were composed of a shoot apex, a closely arched leaf primordium, sometimes accom-

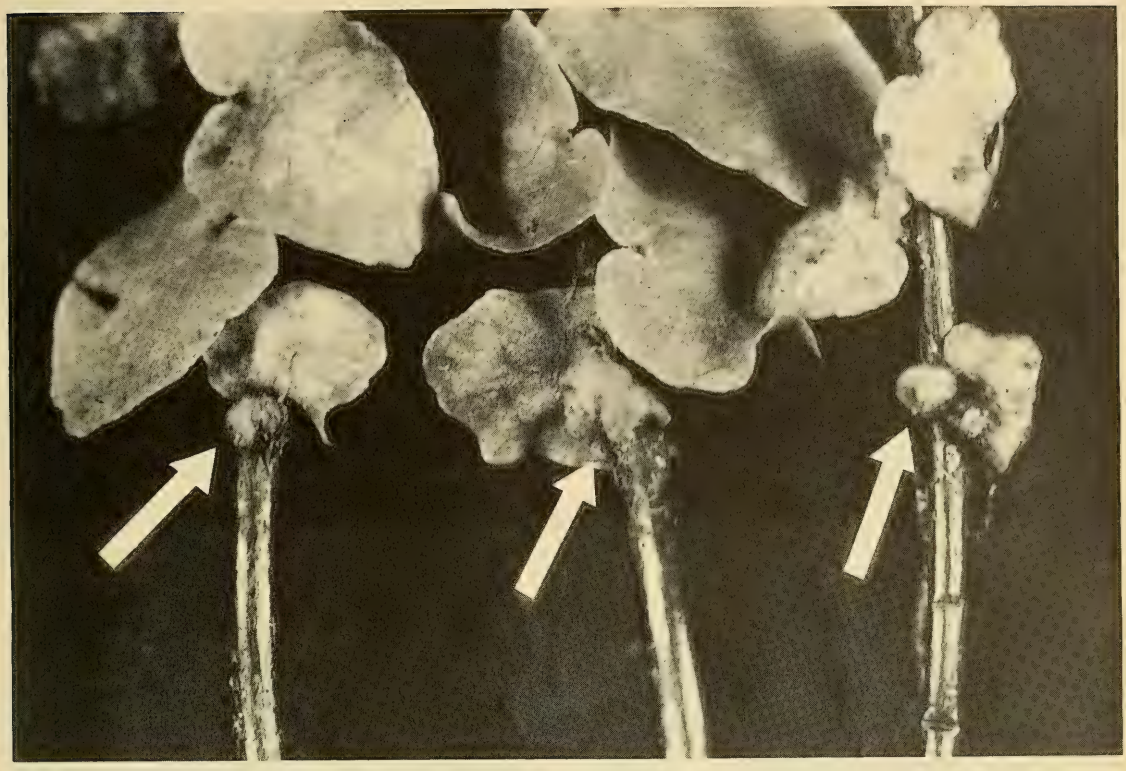

FIGURE 4. Buds at bases of basal pinnae of *Asplenium platyneuron.*

panied by a second, much smaller primordium, and masses of narrow clathrate scales around the apex and primordia. Roots are found on the more fully developed proliferations on which the leaf primordia have expanded. Similar proliferations have been found in the southern Appalachian populations of *A. monathes,* especially those grown in culture (Wagner, unpublished data).

Unless the buds have formed leaves they are difficult to detect, as they occur at the bases of the lowest pinnae and usually on only a single frond per plant which is buried in a mass of 10–20 other fronds. Among 250 plants at three localities which were studied intensively, proliferations were found on 1 out of 6 plants. The buds were found on both fertile and sterile fronds, but were almost always borne singly on one leaf of the plant.

Most of these buds probably die back with the blade and upper portion of the stipe, but under certain conditions they come in contact with the soil at the base of the mother plant and produce new, separate plants by decay of the connection between the bud and the mother leaf. This accounts for the clusters of plants which occur at certain sites, particularly in shaded, moist, woodland habitats.

Mickel (1976) wrote that in *Asplenium exiguum*, which normally grows in dry habitats, the frequency of proliferation increases enormously if the plants are grown under 100% humidity. To see if available moisture also stimulated the formation of leaf buds in *A. platyneuron*, we sampled three populations in Michigan from dry, grassy hillsides and from nearby shaded, moist bottoms at the edges of woods. Whole plants were collected and brought back to be inspected for buds. On the drier more open sites, only 4% (4/108) of the individuals bore proliferations, while in the more moist, more shaded sites, 27% (37/138) had them. Budding, while apparently a genetic possibility for all Ebony Spleenwort plants, appears to be influenced by the environment. We tried unsuccessfully to force nonproliferous old fronds to produce buds by laying them on wet sphagnum or wet sand under high humidity. This suggests that bud formation is initiated during the early ontogenetic stages of the fronds in the spring and that by fall the tissues have matured and will not dedifferentiate.

Occurrence of Incised Variations

Plants which have the pinnae of both the fertile and sterile leaves deeply incised, giving the plants a ruffled appearance (Figure 5), have been given the name *Asplenium platyneuron* var. *incisum*. Taylor et al. (1976), who reviewed the nomenclature and identification of the infraspecific taxa of the Ebony Spleenwort, characterize var. *incisum* as having pinnae which are "doubly serrate to deeply incised; all or nearly all of the pinnae cut less than 4/5 of the way to the midrib."

The geographical and taxonomic significance of this variety relative to typical *A. platyneuron* has been variously interpreted. Some authors, such as Shaver (1954), have considered it to be a coastal race of *A. platyneuron*, while others, such as Correll (1956), have considered it to be only a shade-induced environmental form. Distribution maps (Shaver 1954; Steyermark 1963; Taylor and Demaree 1979) show it to be scattered throughout the range of *A. platyneuron*.

An Ebony Spleenwort population in Lyndon Township, Washtenaw County, Michigan, which contained plants conforming to var. *incisum*, was studied to determine whether this taxon has an environmental or genetic basis. Thirteen samples were taken from a 20 × 20 m area, each composed of the largest frond from every plant within a plot of 2.3 m^2. Voucher specimens from this site are *Wagner 79419* (MICH). The samples were uniformly spaced and included plants both low and high on the hillside and in both sun and shade. The collected fronds were scored for six characters thought to be correlated with the incised condition: greater frond length and width, greater maximum pinna length and width, greater number of pinnae, and non-confluent sori. In addition, pinnae from typical *A. platyneuron* and from var. *incisum* were cleared and stained for comparison of their venation and soral characters.

Of 204 plants sampled, 27 were assignable to var. *incisum*, 165 to the typical variety, and 12 were more or less intermediate (Figure 6, c and e). These identifi-

FIGURE 5. *Asplenium platyneuron* var. *incisum*, Washtenaw County, Michigan, showing ruffled appearance caused by overlapping pinna lobes.

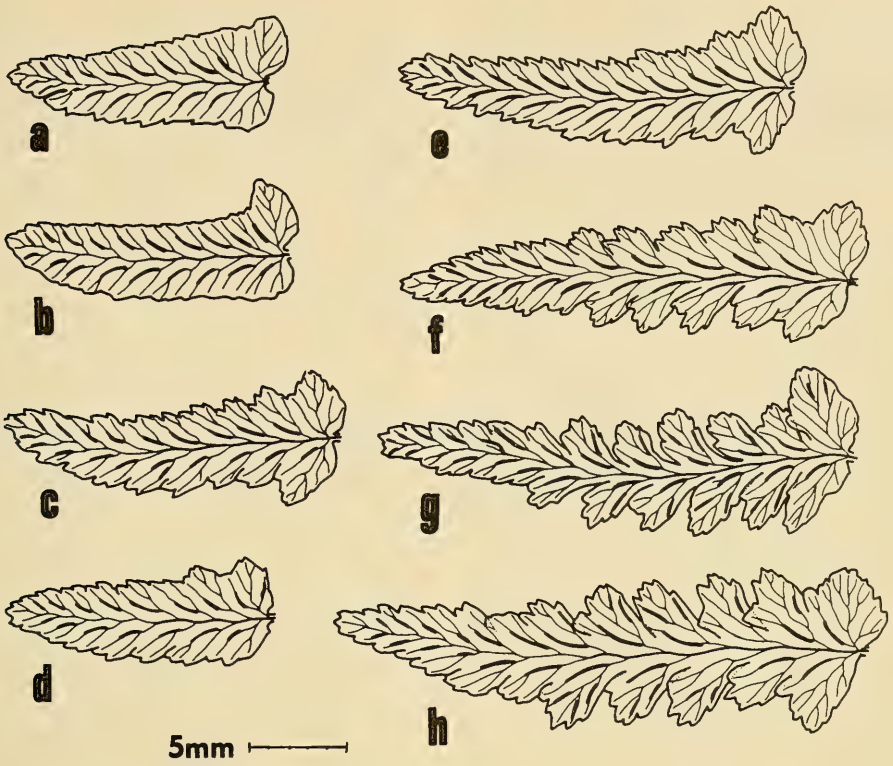

FIGURE 6. Variation in pinna form in *Asplenium platyneuron*: a and b, var. *platyneuron*; f, g, and h, var. *incisum*; c, d, and e, intermediate.

cations were based solely on pinna incision, as there was no significant correlation found between the other characters examined and the incised condition. The plants of var. *incisum* were scattered at random, making up 0–20% of the plants in each plot. There was no obvious frequency gradient from plot to plot in the sample area.

Extremely well-developed plants of var. *incisum* differed from typical plants in several morphological features having to do with the increase in lobing and surface area of the pinnae (cf. Figure 6, a and b with f, g, and h). Greater dissection of the pinnae is accompanied by an increase in the number of quaternary and higher-order veins, an increase in the number of ultimate veinlet endings in each vein complex, the occurrence of several sori per lobe on ultimate higher-order veins, the change from a dichotomous branching plan of the lateral veinlet system to a sympodial one, and the overlapping of pinnule lobes. This last character is visible on pressed specimens, although the ruffling of the pinna lamina found in the living state in *incisum* is not.

As a further investigation on the nature of var. *incisum*, plants of it and of the typical variety were dug up and grown indoors under uniform conditions for several months. Both varieties retained their respective morphologies in the new leaves they produced during this period.

Discussion

We have documented the range expansion of the Ebony Spleenwort, but it is still not clear why this fern did not undergo its spread before the 1960s, as disturbed habitats and old farmlands and fields have been available for over a century. Perhaps there has been a much greater area of second growth available than in the more distant past. Climatic warming trends may have also played a role (cf. Britton 1977). We may be witnessing an entirely statistical phenomenon of population growth, and the species may have existed at a low level for a much longer period and over a much wider range than we have thought. As the populations built up, the spores produced increased geometrically, and what was a trivial spore

shower in the Great Lakes region in 1900 is now a massive fallout. The leading edge of the range is clearly heading northward, and the advent of this species in new areas of Canada, north of Lake Superior and Lake Huron, is expected.

In comparison with other native *Asplenium* species, *A. platyneuron* has a number of characteristics that enable it to compete more aggressively with other plants. Its ability to grow on the ground in addition to rock surfaces allows it to invade areas where outcrops are absent, as in much of southern Michigan and Ontario. The tall, erect sporophylls enable the plant not only to produce large numbers of spores but to release them efficiently into the airstream. The condition of dimorphy is unusual in asplenioid ferns and its presence in this species may be a strong factor in its success (cf. Wagner and Wagner 1977, p. 260, Tables 1 and 2). The starch storage in the petiole bases provides the plant with a ready supply of food for quick development in the spring and for the production of fronds large enough to overtop competing vegetation. In this respect Ebony Spleenwort is like species of a number of common terrestrial fern genera such as *Onoclea, Dryopteris,* and *Athyrium*. Colonization of available habitats, particularly those in shaded, moist bottomlands, is facilitated by the production of new plants from the foliar proliferations. Finally, the origins of many populations are probably traceable to single spores, as intragametophytic mating has been shown to be possible in a large number of ferns (Klekowski 1971, 1972); this may explain why many of the reports of Ebony Spleenwort in the 1950s and 1960s were only of single plants. As shown by our studies in the George Reserve, such plants are capable of giving rise to local populations, even in forests.

As a result of examining plants which could be referred to the infraspecific taxa forma *proliferum* and variety *incisum*, we conclude that neither should be treated as a true taxonomic variety (cf. Wagner 1960). By extrapolation of these studies to the other infraspecific taxa of *A. platyneuron* recognized by Taylor et al. in 1976 (f. *furcatum*, var. *platyneuron,* f. *hortonae,* var. *bacculum-rubrum*), we conclude that none of them merit the designation variety, and question the value of giving them taxonomic names at all. Proliferous leaves have been found on plants "otherwise referable to var. *platyneuron,* var. *incisum*, or var. *bacculum-rubrum*" (Taylor et al. 1976), and our observations suggest that bud formation is a normal potentiality of the Ebony Spleenwort. The only way to tell a plant of forma *proliferum* is to find a bud on one of its leaves, as usually all of the other leaves lack it, a trivial basis for the recognition of a formal taxon. Plants of the "variety" *incisum* occur throughout the range of the Ebony Spleenwort at low frequencies and grade into the typical "variety," criteria for recognition of a weak form at best (cf. Wagner 1960).

Of the remaining four taxa, all but forma *hortonae*, a rare bipinnate-leaved, entirely sterile form, have been found in the Great Lakes area. The remaining three are the typical "variety" (var. *platyneuron*), forma *furcatum,* and "variety" *bacculum-rubrum*. Forma *furcatum* is the name given to plants in which the rachis forks repeatedly; such crested forms, caused by the repeated abortions of the apical cell, are well known in ferns, having been designated with formal nomenclature for at least 11 North American taxa. "Variety" *bacculum-rubrum,* characterized by Taylor et al. (1976) as a southern "variety" with fertile fronds up to 70 cm long, up to 70 pairs of pinnae per frond, and with pinnae frequently serrate-incised and over 3.5 cm long, has been collected in Cass County, Michigan (*Wagner* 73431, MICH). So far as we can determine, the taxon *bacculum-rubrum* embraces only the largest plants from the southern part of the range of *A. platyneuron*, and these, like "variety" *incisum*, occur at low frequencies in collections and presumably in populations; of 55 *A. platyneuron* specimens from the coastal plain from Virginia to Texas at MICH, only 5 could be identified as var. *bacculum-rubrum*, while

TABLE 1—Comparison of infraspecific taxa of *Asplenium platyneuron*

	incisum	*bacculum-rubrum*	*proliferum*	*hortonae*	*furcatum*
Distribution	Sporadic	Clinical north to south	Sporadic	Sporadic	Sporadic
W. Great Lakes incidence	Rare	Rare	Common	Unknown	Unknown
Transition to typical form	Gradual	Gradual	Gradual	Abrupt	Gradual
Major character	Incised pinnae	Pinnae linear, more than 3 cm long	Presence of buds	Bipinnate	Forked midrib
Control	Genetic or modification	Modification	Modification	Genetic	Genetic or modification

most specimens were indistinguishable from typical plants from New England and Ontario. There is no real break in the variation pattern, and the characters are primarily those of size alone. Accordingly, we believe that if this taxon must be recognized taxonomically, it should be as a form. When specimens are discovered in the Great Lakes area that conform to *"bacculum-rubrum,"* they do not constitute range extensions, but only extreme variations of local populations.

The characteristics of the described nontypical infraspecific taxa of *A. platyneuron* are summarized in Table 1. In all cases we appear to be dealing with potentialities—for forking fronds, incised pinnae, giant fronds with long pinnae, and foliar proliferation—which reflect different aspects of the adaptations and genetic constitution of the Ebony Spleenwort. Similar situations in the animal world, such as the color phases of hawks, the budding of hydras, and the regeneration of new tails by lizards, have not been saddled with formal nomenclature, and we see no reason why it is appropriate here. It should be sufficient to recognize that the Ebony Spleenwort is a dynamic and variable species, keeping in mind that the recognition of these taxa was historically important in pointing out its capabilities.

Acknowledgments

The information presented in this paper represents the collaboration of many workers, especially H. E. Ballard, Jr., J. M. Beitel, D. J. Bay, D. M. Britton (Ontario), T. J. Carlson, A. J. Cooper, T. Crovello (Indiana), T. F. Daniel, G. J. Gastony (Indiana), the late D. J. Hagenah, Matt Heumann, J. Morton (Ontario), J. H. Peck (Iowa, Minnesota, and Wisconsin), R. A. Pippen, A. A. Reznicek (Ontario), C. J. Sheviak (Illinois), W. C. Taylor (Wisconsin), R. L. Stuckey (Ohio), Olive Thompson (Wisconsin), F. S. Wagner, and J. R. Wells. Those persons who supplied data from outside Michigan are so indicated. Michael K. Hansen aided us in the design of data collection, and the authorities of Park Lyndon, of Washtenaw County, Michigan, and the E. S. George Reserve of The University of Michigan, kindly permitted us to make collections. R. J. Ayotte contributed much of the work on the incidence of proliferations.

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Received 15 July 1980
Accepted 6 October 1980

Distributional History of *Juncus compressus* (Juncaceae) in North America

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Stuckey, Ronald L. 1981. Distributional history of *Juncus compressus* (Juncaceae) in North America. Canadian Field-Naturalist 95(2): 167–171.

Juncus compressus Jacq., native to Europe and portions of western Asia, is a poorly known member of the North American wetland flora. Although sometimes misidentified as *J. gerardii,* verified records of its occurrence date from 1881 to the early 1900s. These early records are from a coastal locality in Maine and in Newfoundland, along the St. Lawrence River in Quebec, the Finger Lakes region of New York, and Salt Lake City, Utah. Within the past 30 years, *J. compressus* has become more widespread, and records have been obtained from in and near Toronto, Ontario, from southern Manitoba, and from five states, namely Colorado, Minnesota, Montana, Wisconsin, and Wyoming, all west of the Great Lakes. The plants are perennial, and they invade and inhabit salt marshes, man-created saline habitats, ditches along highways and railroads, limestone quarries and calcareous shores, and banks of canals and roadsides. Its recent discovery from six widely spaced localities in Wyoming suggests that the species may be established in other areas of western United States, even though it is not included in the most recent floristic treatments of that region.

Key Words: Juncaceae, *Juncus compresus, J. gerardii*, rush, wetland flora, non-indigenous, introduced, distributional history, halophyte, North America.

During a study of the migration and establishment of *Juncus gerardii* (Juncaceae) in the interior of North America (Stuckey 1980), it became apparent that a morphologically similar species, *J. compressus* (Figure 1), has sometimes been confused with and misidentified as *J. gerardii*. This paper presents documentation for the known distributional history of *J. compressus*, Flattened Rush, an apparently non-indigenous member of the North American wetland flora. Native throughout most of Europe and portions of western Asia, *J. compressus* was first reported for North America by Bartlett (1906). This record was based on specimens obtained in 1904 by Arthur S. Pease (*6312, 6312A, 6313,* GH), who discovered the plants as abundant on the Plains of Abraham near the city of Quebec. Bartlett pointed out the morphological differences between *J. compressus* and *J. gerardii*, and one or more of these differences (Table 1) have since been used as key characters in several manuals, for example, Fernald (1950), Gleason (1952), Hermann (1975), Scoggan (1978), and Wiegand and Eames (1926). Like *J. gerardii, J. compressus* invades and inhabits salt marshes, man-created saline habitats, and ditches along highways and railroads, limestone quarries and calcareous shores, and banks of canals and roadsides. Marie-Victorin (1929) believed that the plants may have been introduced at an early date with military forage.

Examination of herbarium specimens now reveals that *J. compressus* was present in North America prior to Bartlett's report as verified from two specimens. One specimen was obtained on 30 July 1881 by Agnes Saunders (DAO) from a "bog" near shore at Great Chebeag, Casco Bay, Maine. This specimen, mounted on the same sheet with a collection of *J. gerardii* that apparently was also obtained at the same locality, represents a record that she would have secured while on a vacation trip, rather than one from her home area near London, Ontario, where most of her plants were collected (Dore 1970). Another specimen from Murray Bay, Quebec, obtained on 20 August 1902 by W. W. Eggleston (*2974*, GH, NY), represents the voucher for the notation by Robinson and Fernald (1909), who considered the species as "possibly naturalized from Eu[rope]." The report of *J. compressus* from Coney Island, New York, by Smith (1945) is based on a plant of *J. gerardii* (CU) collected in 1879 by an unidentified collector.

Elsewhere in the eastern United States, *J. compressus* has been reported from the Finger Lakes region of New York. Wiegand and Eames (1926) considered the species "introduced with sand and other material brought to a glass factory formerly existing near the salt works" at Ithaca, Tompkins County. Wiegand and Eames considered its arrival shortly before 1895, when the plants were first detected. The species had not been reported earlier from the area (Dudley 1886).

The following records have been verified as *J. compressus* from Tompkins County: marsh near D. L. & W. coal dump, Ithaca, 22 July 1895, *K. M. Wiegand s.n.* (CU); marsh W of Glass Works near D. L. & W. dump, 22 July 1895, *K. M. Wiegand s.n.* (CU); at edge of marsh in soft mucky soil, near Ithaca Salt Works, Ithaca, 7 July 1913, *E. L. Palmer 269* (CU, GH, TRT); brackish pond near salt works, Ithaca, 21 July 1916, *E. P. Metcalf 6139* (CU); salt works, flats, Ithaca,

FIGURE 1. *Juncus compressus*, showing upper portion of plant taken from specimen obtained at Oshkosh, Winnebago County, Wisconsin, 11 July 1974 (*Harriman 10,186*, OS).

TABLE 1—Morphological differences between *Juncus compressus* and *J. gerardii* based on an examination of plants by the author and statements by Fernald (1950), Gleason (1952), Hermann (1975), Scoggan (1978), and Wiegand and Eames (1926)

	J. compressus	*J. gerardii*
Stamen length	About half as long as the perianth segments	About equal in length to the perianth segments
Anther length	About as long or twice as long as the filaments	About three to four times as long as the filaments
Perianth color	Light brown with greenish center and membranaceous margin	Dark brown to blackish with green central stripe
Style length	Shorter than the ovary	Equal to or longer than the ovary
Capsule length	About one and one-half times as long as the perianth	Shorter than or barely exceeding the perianth
Capsule shape	Subglobose or globose-obovoid	Subellipsoid or ellipsoid-ovoid
Primary involucral bract	Usually longer than the inflorescence	Usually shorter than the inflorescence

30 July 1919, *K. M. Wiegand 11731* (CU); E bank of inlet, Ithaca, 31 July 1919, *K. M. Wiegand 11732* (CU, MO).

Wiegand and Eames (1926) also reported the species about the railroad station at Freeville, but their specimen (*11733*, CU) is *J. gerardii*. The record of *J. compressus* from nearby Onondaga County is based on plants (CU) obtained in 1912 from a salt marsh at Syracuse (Smith 1945). The species was also listed as a member of the flora of Onondaga County (Faust 1961; Bye and Oettinger 1969) and the Cayuga Quadrangle (Clausen 1949).

The spread of *J. compressus* has been more extensive in Canada than in the United States. Following its early discovery at Murray Bay (La Malbaie) in 1902 and near the city of Quebec in 1904, the species has been located at several sites along the St. Lawrence River.

The following additional specimens from Quebec arranged chronologically have been examined: dry soil, Heights of Abraham, 5 August 1910, *C. S. Williamson 1112* (NY); berges du canal de Chambly, Ile Ste. Thérèse, St. Jean County, 14 juillet 1932, *M.-Victorin and R.-Germain 49134* (GH, TRT); narrow channel of Richelieu River, Chambly to St. Jean, Chambly County, 13 September 1932, *M.-Victorin and K. M. Wiegand s.n.* (CU, MO, NY); abondant au revers du remblai du canal, Ile Ste. Thérèse, près de St. Jean, St. Jean County, 20 septembre 1932, *M.-Victorin and R.-Germain 44667* (DAO, GH); introduit le long du canal en gazon abondant, Ile Ste. Thérèse, St. Jean County, 25 août 1933, *M. Raymond 3498* (TRT); très rare récolté près du pont qui mène à l'île, Ile Ste. Thérèse, 28 août 1933, *M. Raymond 126731* (CAN); dans une prairie saumâtre au bord de la mer, Les Emoulements, Charlevoix County, 16 juillet 1935, *M.-Victorin, R.-Germain, and R. Meilleur 43615* (CU, DAO); sur la grève, Pointe-au-Pic, Charlevoix County, 9 août 1937, *C. Morin 897* (DAO); berges du canal Chambly St. Jean, 7 août 1943, *M.-Victorin, R.-Germain, E. Rouleau, and A. Blain 2158* (DAO, GH, MICH); sommet de la grève, St. Joachim, Cap Tourmente, 25 août 1950, *Y. Desmarais 1237* (CAN, DAO); talus du côté de St. Jean, Ile Ste. Thérèse, St. Jean County, 2 août 1953, *L. Cinq-Mars and M. Raymond s.n.* (DAO); dans une prairie humide ½ mi [0.93 km] au sud du Cap, St. Joachim, Montmorency County, 6 juillet 1960, *G. Lemieux 67084* (DAO); anse-aux-foins, dans un petit misseau, St. Fulgence, cté Chicoutimi, 18 juillet 1973, *J. Cayouette 73-516* (TRT); open alkaline roadsides of highway, N side of Hwy 20, 2 mi [3.7 km] E of

Pointe-Claire, just E of Boul des Sources, Dorval, Montreal County, 10 June 1976, *P. M. Catling, A. A. Reznicek, S. M. McKay, and K. M. Lindsay 81* (CAN, DAO, TRT); salt marsh, near Gaspé, S side of Gaspé Bay, Gaspé County, 10 August 1978, *P. M. Catling and F. H. Catling s.n.* (TRT).

In Ontario, *J. compressus* was apparently first noted by Fassett (1933) based on a specimen obtained in 1931 from a small stream near a highway along the Mississippi River near Ottawa, Carleton County (*Fassett 13280*, CAN, GH). Since then the species has been obtained from several localities in Ontario particularly along railroads and in saline wetlands in areas near Ottawa, Toronto, Hamilton, and as far north as Cochrane.

The following additional specimens from Ontario have been identified, arranged by county: Carleton County: in shallow soil over shale, Rockliffe Park, along Ottawa river near boathouse below "lookout," 4 September 1947, *J. A. Calder 1641* (DAO); a small clump in alluvial, perhaps saline, pasture, at Mississippi River (about 5 mi [9.3 km] SE of Arnprior, 27 mi [50 km] W of Ottawa), 19 June 1959, *W. G. Dore and W. J. Cody 17426* (DAO, TRT). [Cochrane District]: le long de la voie ferré, Cochrane, 20 August 1946, *E. Lepage s.n.* (DAO). Halton County: lining ditch in a distinctive dark-green band in Nelson Quarry, near Burlington, 16 July 1975, *G. W. Dore 25444* (DAO, TRT). Ontario County: floodplains and flanking slopes, from confluence of Little Rouge and Rouge Rivers S to Lake Ontario, 4 July 1973, *J. L. Riley s.n.* (TRT); roadside, along Highway 69 near Rathburn, Mara Township, 15 July 1979, *P. M. Catling s.n.* (OS, TRT). Peel County: one clone seen, disturbed clay soil on floodplain, Credit River just N of Erindale College campus, 16 June 1977, *A. A. Reznicek and S. A. White s.n.* (TRT). Simcoe County: locally dense, wettest section of roadside ditch, Conc. XIII, lot 1, Vespra Township, 22 July 1972, *R. S. W. Bobbette 2851* (TRT); moist ground by end of road along drainage canal, West Gwillimbury Township, 4.5 mi. [8.3 km] N NE of Bradford, 15 July 1973, *R. S. W. Bobbette 3830* (DAO); solitary dense patch, NW side of Hwy 27, 5 mi [9.3 km] S of Bondhead, Conc. I, Lot 23, Tecumseth Township, 29 June 1975, *A. A. Reznicek 14541* (TRT). Wentworth County: marsh, banks of old creek, Royal Botanical Gardens, Hamilton, 17 July 1954, *Tamsalu 1419* (HAM); in pools, edge of Queen Elizabeth Highway, 2 km NW of Fifty Road near Stoney Creek, Saltfleet Township, 6 October, *P. M. Catling and K. L. Catling s.n. (OS, TRT).* York County: moist sandy soil in open location, Toronto Island, 9 August 1972, *P. M. Catling and S. M. McKay s.n.* (DAO); on landfill ca. 5 years old, wet ground at foot of Leslie Street, Toronto, September 1972, *P. M. Catling s.n.* (CAN, TRT); additional specimens from the Leslie Street locality have been obtained by Catling and McKay on 1 July 1973 (TRT), 10 November 1974 (TRT), July 1975 (TRT), October 1975 (TRT), 1 August 1976 (DAO, TRT), 8 August 1976 (CAN, TRT); sandy lake shore, Hanlan's Point, Toronto Island, 25 July 1974, *D. Hoy, H. Saifi, and N. Purcell s.n.* (TRT); in snow dumping area opposite Don Valley Brickyard, Don Valley, Toronto, 19 October 1974, *P. M. Catling and S. M. McKay s.n.* (DAO); in wet depression receiving runoff from rock salt storage depot opposite Don Valley Brickyard, Don Valley, Toronto, 20 October 1974, *P. M. Catling and S. M. McKay s.n.* (CAN, TRT); open alkaline soil by railway yard at Bathurst Street underpass, just N of Front Street, just E of Old Fort York, Toronto, 21 August 1977, *P. M. Catling and K. L. McIntosh s.n.* (TRT); alkaline ditch receiving salty runoff, edges of Don Valley Parkway, near Bloor Street, Toronto, 13 October 1979, *P. M. Catling s.n.* (OS, TRT).

In the maritime provinces, *J. compressus* was first discovered in Newfoundland, in boggy meadows and wet grassy slopes at Birchy Cove, Curling, 7 September 1910 by Fernald and Wiegand (*2986*, CAN, CU, GH, NY). Two records, one from Inverness County and one from Richmond County, have been cited for Nova Scotia (Erskine 1951), but specimens verifying these localities have not been found. The earliest report for Nova Scotia (Roland 1945) is *J. gerardii* based on a specimen obtained in 1930 from Guysborough by J. Rousseau (*35358*, CAN). Furthermore, the report of *J. compressus* for Prince Edward Island by Erskine (1960) is also *J. gerardii*, having been based on specimens collected in 1912 from Charlottetown by Fernald, Long, and St. John (*7140*, CAN, GH, MICH, MO, NY).

West of the Great Lakes region, *J. compressus* was first obtained from Manitoba in 1950 at Brandon (Stevenson 1957), and subsequently at Duck Bay, Lake Winnipegosis, and northeast of Duck Mountain (Scoggan 1957). Later, Löve and Bernard (1959) noted it from a roadside south of Kleefeld in the Otterburne area.

Specimens seen from Manitoba are wet flats W of Exhibition grounds, Brandon, 16 July 1950, *G. Stevenson 201* (DAO); locally common around Brandon, 3 August 1954, *G. Stevenson 882* (CAN); Fosse, coin nord-ouest du terrain d'Exposition, Brandon, 3 juillet 1959, *B. Boivin, G. Stevenson, and E. Laishley 13162* (DAO, GH, NY, TRT).

In the United States west of the Great Lakes region, *J. compressus* was first obtained in 1909 from Salt Lake City, Utah, based on a specimen of M. E. Jones (*s.n.*, NY) which had been identified as *J. gerardii*. In the *Intermountain Flora*, Cronquist (1977) did not include *J. compressus*.

Verified records of *J. compressus* are known from five other states, all since 1950 as follows: Montana: Beaverhead County: marshy roadside ditch, 9 mi [16.7 km] S of Wisdom, 1955 (Hermann, 1975). Minnesota: Kittson County: roadside at Caribou, 1962 (*J. W. Moore 26083*, TRT, mapped erroneously as *J. gerardii* by McGregor and Barkley (1977). Colorado: Larimer County: open wet soil adjoining bait minnow ponds, Colorado State University foothills campus, Fort Collins, 1967; sedge meadow south of Spring Canyon, 5 mi [9.3 km] SW of Fort Collins, 1971 (Hermann 1975). Wisconsin: Winnebago County: along grassy edge beneath U.S. 41 overpass at state route 21, on the S side of route 21 only, and on to the lawn at the Howard Johnson's, Oshkosh, 1974 (Harriman and Redmond 1976). Wyoming: Carbon County: around pool in floodplain of Medicine Bow River, ½ mi [0.93 km] N of Medicine Bow, 1973 (*S. Stephens*

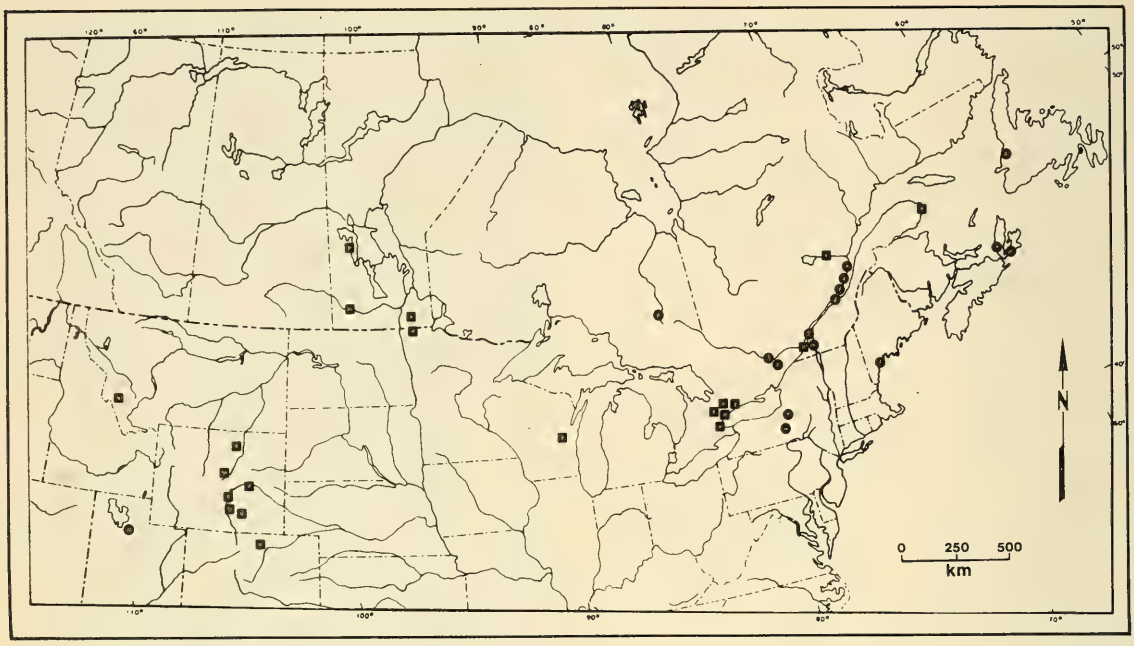

FIGURE 2. The distribution of *Juncus compressus* in North America based on herbarium specimens examined and reliable literature citations. Dots represent localities where plants have been recorded before about 1950, and squares represent localities where plants have been obtained since about 1950.

70504, KANU, NY); same locality, 31 July 1979, *B. Nelson and R. Hartman 4215* (RM); abundant in wet sandy soil around pool, Seminoe Reservoir, ca. 16 air km SSE of Seminoe Dam (T24N R84W S14, 24), ca. 1950 m, 11 July 1979, *R. Hartman 9921* (RM). Converse County: North Platte River, ca. 10.4 air km E of Glenrock (T33N R74W S9), ca. 1524 m, 9 August 1979, *K. Dueholm 8816* (RM). Johnson County: ca. 27.2 air km SE of Buffalo (T48N R81W S24), ca. 1370 m, 29 June 1979, *K. Dueholm 7447* (RM). Natrona County: North Platte River, ca. 1.6 air km E of Pathfinder Reservoir Dam (T29N R83W S19), ca. 1740 m, 11 July 1979, *R. Hartman 9958, 9959* (RM); oil field, ca. 6.8 air km N of Waltman (T36N R86W S6 and R87W S1), ca. 1900 m, 12 July 1979, *R. Hartman 10037* (RM).

The recent discovery of *J. compressus* from six widely spaced localities in Wyoming suggests that the species may be established in other areas of western United States even though it is not included in two of the most recent floristic treatments of the region (Cronquist 1977; Dorn 1977).

The known distribution of *J. compressus* in North America is mapped based on the above cited records (Figure 2). The map shows the range of the species before about 1950 to be confined to Newfoundland, Nova Scotia, Quebec, eastern Ontario, Maine, New York, and Utah. Since then *J. compressus* has been obtained from additional localities in Quebec, and has appeared in the Toronto region in Ontario, southern Manitoba, Colorado, Minnesota, Montana, Wisconsin, and Wyoming. The plants are perennial, and once they invade an area, they persist, as has been verified by the recent records from the St. Lawrence River valley and the Toronto area. Current records, however, have not been seen from the early reported localities in Maine, New York, Utah, and Newfoundland.

Acknowledgments

My thanks are extended to Paul Catling, who provided the records and identifications of the specimens at TRT; to Ronald Hartman, who provided the records and identifications of the specimens at RM; to James S. Pringle, who provided data on the single specimen at HAM; and to A. E. Spreitzer, for preparing the photograph. My thanks are also extended to the curators of the herbaria who made specimens available. Those herbaria in which I have examined specimens are CAN, CU, DAO, GH, MICH, MO, NY, OS.

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Received 9 July 1980
Accepted 14 October 1980

Le régime alimentaire du Coyote (*Canis latrans*) et du chien errant (*C. familiaris*) dans le sud du Québec

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Bergeron, Jean-Marie, et Pierre Demers. 1981. Le régime alimentaire du Coyote (*Canis latrans*) et du chien errant (*C. familiaris*) dans le sud du Québec. Canadian Field-Naturalist 95(2): 172–177.

L'analyse de contenus stomacaux de 84 Coyotes (*Canis latrans*) et 58 chiens errants (*C. familiaris*) échantillonnés dans un milieu agro-forestier nous a permis d'identifier les éléments importants de leur alimentation. Beaucoup d'indices portent à croire que les Coyotes de la région se nourissent de charogne puisqu'une grande partie des contenus digestifs est composée de restes d'animaux domestiques comme les bovins (*Bos taurus*) et le porc (*Sus scrofa*). Par contre, les mammifères sauvages constituent un élément moins important du régime alimentaire de ces prédateurs. Pour le Coyote, viennent par ordre d'importance, le Lièvre d'Amérique (*Lepus americanus*), les petits mammifères, le Cerf de Virginie (*Odocoileus virginianus*), la Marmotte Commune (*Marmota monax*) et le Raton Laveur (*Procyon lotor*). Cependant, des restes de cerfs ont été analysés dans plus du tiers des chiens examinés en hiver, ce qui en fait un animal très nuisible face à la survie hivernale des cerfs. Certains éléments de végétation et les oiseaux complètent le régime alimentaire de ces prédateurs.

Mots clés: Coyote, chien errant, prédateur, régime alimentaire.

Bergeron, Jean-Marie, et Pierre Demers. 1981. Le régime alimentaire du Coyote (*Canis latrans*) et du chien errant (*C. familiaris*) dans le sud du Québec. Canadian Field-Naturalist 95(2): 000–000.

We identified the components of their diet from the stomach analyses of 84 Coyotes (*Canis latrans*) and 58 domestic dogs (*C. familiaris*) trapped in the forested agricultural land of southeastern Quebec. Domestic animal carrion, especially cattle (*Bos taurus*) and hogs (*Sus scrofa*), was very important for Coyotes. Wild mammals were not an important food source for Coyotes but Snowshoe Hares (*Lepus americanus*), small mammals, White-tailed deer (*Odocoileus virginianus*), Woodchucks (*Marmota monax*), and Raccoons (*Procyon lotor*) regularly occurred in that order in their diet. Deer remains, however, were identified in more than a third of the dogs examined in winter. Some avian and vegetal components were classified as secondary food sources for both species.

Key Words: Coyote, wild dog, predators, diet.

Depuis la dernière décennie, les populations de Coyotes (*Canis latrans*) et de chiens errants (*C. familiaris*) ont tellement augmenté dans les Cantons de l'Est au Québec qu'ils entrent maintenant en conflit avec plusieurs secteurs d'activités humaines. Par exemple, dans les milieux agro-forestiers, leur présence soulève une polémique sérieuse et met en évidence l'opportunisme de ces prédateurs. En effet, du printemps à l'automne, ces prédateurs s'attaquent fréquemment aux animaux domestiques, jeunes et adultes, tandis qu'en hiver, ils doivent se nourrir d'animaux sauvages. Cette situation n'est pas particulière à notre région et a été vérifiée à maints endroits en Amérique du Nord où les pratiques agricoles de petite et moyenne envergure sont effectuées dans un encadrement forestier.

Depuis 1935, de nombreuses analyses du régime alimentaire de ces prédateurs ont été effectuées aux Etats-Unis. Cependant, peu d'études canadiennes autres que celles de Murie (1935), Pastuck (1974) et Nellis et Keith (1976) ont été entreprises dans ce domaine. Au Québec, les seules études que nous connaissons sont celles de Jean-Paul Blais,Ministère du Tourisme, de la Chasse et de la Pêche (MTCP), Shawinigan, rapport d'étape, 1974 et de Messier et Barrette (1979). Dans la première, l'examen macroscopique des contenus stomacaux de 81 Coyotes capturés dans la région de Shawinigan a permis de constater dans 70% des cas un bol alimentaire constitué de diverses espèces de mammifères dont les plus importantes sont représentées par les bovins domestiques (13%) et le Lièvre d'Amérique (*Lepus americanus*) (8%). Dans la seconde étude, les auteurs ont étudié le régime alimentaire de Coyotes provenant de régions forestières en se basant sur les crottins et les restes laissés le long de leurs pistes sur la neige. Ils ont trouvé que le Cerf de Virginie (*Odocoileus virginianus*) et le Lièvre d'Amérique constituaient les proies les plus recherchées avec des fréquences d'abondance respectives de 59 et 38%. Ces auteurs ont également noté d'importantes variations de ces deux espèces dans le régime alimentaire au cours de l'année et selon la taille des groupes de Coyotes.

De janvier 1975 à juin 1977, nous avons recueilli les carcasses de Coyotes et de chiens errants provenant de trappeurs des Cantons de l'Est afin d'analyser leur régime alimentaire. Nous voulions par cette comparaison vérifier les changements saisonniers dans l'alimentation des prédateurs et analyser l'importance relative des sources de nourriture de provenance domestique ou sauvage de façon à jeter les bases d'un aménagement de ces prédateurs par les organismes concernés.

La région étudiée

Les Cantons de l'Est (Figure 1) sont limités au sud par la frontière canado-américaine (45°00'N) et au nord par le piémont appalachien (46°30'N). L'encadrement est et ouest se fait à 70°30' et 73°00' de longitude ouest. Le territoire couvre environ 20 000 km^2 et comprend un relief peu accidenté dans l'ensemble, ce qui permet un bon drainage de sols sédimentaires à fort potentiel agricole et de podzols offrant de bonnes aptitudes forestières.

Les versants fertiles et bien drainés favorisent la croissance de certains feuillus comme l'Erable à Sucre (*Acer saccharum*), l'Erable Rouge (*A. rubrum*), le Merisier (*Betula alleghaniensis*) et de peuplements conifériens comme l'Epinette Blanche (*Picea glauca*), le Sapin Baumier (*Abies balsamea*) et la Pruche (*Tsuga canadensis*).

Le développement du réseau routier a permis l'expansion de l'agriculture dans la portion occidentale. La section centrale possède une vocation agricole et forestière, tandis que l'est demeure un important secteur forestier. La région présente donc une mosaïque agro-forestière dont l'ensemble des composantes passe par une gamme complexe d'exploitations partagées entre l'agriculture et la foresterie.

Matériel et méthodes

L'analyse des contenus stomacaux de Coyotes et de chiens s'est faite selon la technique décrite par Korschgen (1969). Les carcasses nous parvenaient (1) de trappeurs travaillant à leur propre compte dans la région; (2) de trappeurs professionnels employés par le Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), dont la fonction est de trapper les animaux ayant causé des pertes de bestiaux; et (3) d'Agents de Conservation exerçant un contrôle hivernal et printannier près des quartiers d'hiver de Cerfs de Virginie. Les carcasses étaient acheminées au laboratoire d'écologie animale de l'Université de Sherbrooke, munies d'une étiquette indiquant la date et le lieu de capture, le mode de

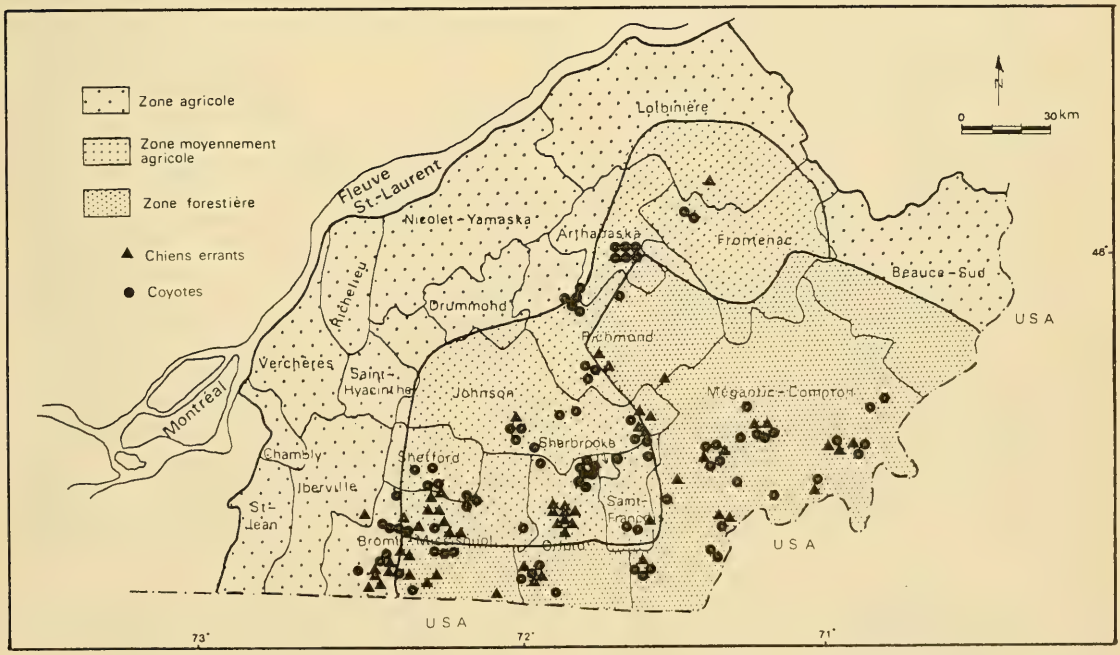

FIGURE 1: Répartition des captures de Coyotes et de chiens errants en fonction de l'utilisation du sol des Cantons de l'Est (Districts électoraux. Ministère des Terres et Forêts, 1973).

trappage, l'appât utilisé, le nom du trappeur et l'habitat dans lequel l'animal était capturé. Celles-ci étaient ensuite âgées et séparées en Coyotes, chiens ou hybrides selon les techniques de Lawrence et Bossert (1967).

Les analyses stomacales ont été effectuées principalement à l'aide d'exemples cuticulaires de poils de mammifères. Nous avons préparé une collection de 400 photographies de référence regroupant 39 espèces de mammifères et d'oiseaux sauvages ou domestiques. Les échantillons de poils prélevés dans les contenus stomacaux étaient montés sur lames pour analyse microscopique, à la façon d'Adorjan et Kolenosky (1969) et comparés à ceux de la collection. Les autres éléments du contenu stomacal étaient identifiés et classés en groupes de façon à exprimer leur fréquence. Nous n'avons pas effectué de mesures volumétriques de composantes étant donné que les structures avaient séjourné plus de 5 h dans l'estomac (Gier 1968).

Résultats et discussion

La distribution géographique des Coyotes et des chiens errants qui nous ont servi pour l'étude apparaît à la figure 1. L'effort de cueillette des carcasses n'est pas réparti uniformément dans les Cantons de l'Est. Les petites concentrations de captures peuvent s'expliquer par l'emplacement des quartiers d'hiver de Cerfs de Virginie, la provenance des plaintes de pertes d'animaux de ferme, le lieu de résidence des trappeurs et leur habileté respective à capturer Coyotes et chiens. La figure montre que la section sud-est forme un bloc forestier contrastant avec la région sud-ouest de la plaine du Saint-Laurent dont la vocation est foncièrement agricole. La moitié de la portion centrale présente des terres non défrichées (MACQ 1965). Ainsi, la majeure partie de notre récolte provient de secteurs forestiers et partiellement agricoles.

La distribution de notre échantillonnage dans le temps est directement fonction de notre approvisionnement en carcasses. Les trappeurs professionnels engagés pour le contrôle des prédateurs des animaux de ferme ont fourni au printemps et à l'été 46% (38/84) des carcasses. La participation des autres trappeurs constitue 39% (33/84) de l'échantillonnage dont les animaux ont surtout été piégés l'automne et l'hiver. Le reste de la cueillette provient du contrôle des prédateurs à proximité des quartiers d'hiver de Cerfs de Virginie par les Agents de Conservation. Ce contrôle nous a également procuré 55% (32/58) des chiens de notre échantillon, alors que la différence, en majorité des captures d'automne, nous est parvenue de trappeurs répartis dans la région.

Bien que la récolte soit assez bien répartie sur 12 mois, il faut tenir compte de la compartimentation saisonnière faite en fonction des objectifs du piégeage ou du contrôle de prédateurs. Cet état de fait rend la comparaison des régimes alimentaires difficile à effectuer puisque beaucoup de chiens ont été piégés près des aires hivernales de Cerfs de Virginie tandis que les Coyotes proviennent de différentes sources.

Les mammifères représentent sans contredit l'élément le plus important du régime alimentaire du Coyote. Nous avons trouvé des restes de mammifères domestiques dans 30% des Coyotes et 28% des chiens analysés (Tableau 1). La présence d'animaux domestiques dans les contenus digestifs du Coyote est particulièrement importante en hiver et au printemps, probablement à cause de la libre disposition d'animaux morts à proximité des fermes. Les bovins (*Bos taurus*) constituent l'élément le plus fréquemment rencontré chez ces prédateurs, totalisant 18% chez le Coyote et 24% chez le chien. Nos résultats se comparent assez bien avec ceux du Québec (Jean-Paul Blais, MTCP, rapport d'étape, 1974), du Manitoba (Pastuck 1974) et des Etats-Unis (Ozaga 1963; Mathwig 1973; Andrews et Boggess 1978; Berg et Chesness 1978). L'élevage du porc (*Sus scrofa*) dans nos régions se fait dans des conditions de rétention très contrôlées. Le fort pourcentage d'indices de porcs dans les contenus digestifs peut s'expliquer soit par l'abondance des carcasses près des fermes, soit par l'utilisation des carcasses aux dépotoirs municipaux.

La faible abondance (2%) du mouton (*Ovis aries*) dans les prédateurs échantillonnés est un peu surprenante. Malgré l'attention particulière apportée à la détection d'indices (laine), nous n'avons pu confirmer par l'analyse des contenus digestifs l'impact réel qu'exerce le Coyote sur les moutons de la région. Bien que nos résultats se comparent avec ceux de Pastuck (1974, 3%), Andrews et Boggess (1978, 5%), et Berg et Chesness (1978, 2%), nous ne pouvons nier l'impact qu'ont les Coyotes et les chiens errants sur le cheptel ovin de la région. Les nombreuses plaintes (P. Demers, chargé du dossier des prédateurs au MLCP (Ministère du Loisir, de la Chasse et de la Pêche) de Sherbrooke) enregistrant la perte d'animaux ou du moins la présence de Coyotes et de chiens errants à proximité des pâturages témoigne du problème de certains éleveurs. L'impact des chiens errants sur les animaux de la ferme est indirect, c'est-à-dire qu'il s'agit le plus souvent de harcèlement que de prédation réelle.

Mathwig (1973) affirme que 20% des pertes en bétail étaient causées par des chiens et Pastuck (1974) précise que les moutons étaient la plupart du temps tués par les chiens. La présence plus fréquente d'indices de bovins chez les chiens plutôt que chez les Coyotes s'explique par la promiscuité avec le bétail ainsi que la proximité des dépotoirs de ferme et des carcasses d'animaux facilement accessibles.

Parmi les mammifères sauvages faisant partie du régime alimentaire des Coyotes nous n'avons pas

TABLEAU 1—Fréquence (pourcentage) des principaux éléments rencontrés dans les analyses stomacales de 84 Coyotes et 58 chiens errants récoltés en différentes saisons

	Printemps		Eté		Automne		Hiver		Total	
Eléments	Coyotes, 22	Chiens, 12	Coyotes, 17	Chiens, 3	Coyotes, 23	Chiens 19	Coyotes, 22	Chiens, 24	Coyotes, 84	Chiens, 58
Mammifères domestiques	40.9	50.0	5.9	0	26.1	15.8	40.9	29.2	29.8	27.5
Bovin domestique (*Bos taurus*)	13.6	41.7	—	—	26.1	10.5	27.3	29.2	17.6	24.1
Porc domestique (*Sus scrofa*)	22.7	—	5.9	—	4.3	5.3	13.6	—	11.9	1.7
Autres[1]	9.1	16.7	—	—	—	—	4.5	—	3.6	3.4
Mammifères sauvages	31.8	25.0	29.4	33.3	43.5	10.5	40.9	25.0	36.9	20.7
Lièvre d'Amérique (*Lepus americanus*)	13.6	—	5.9	—	—	—	4.5	—	6.0	—
Marmotte Commune (*Marmota monax*)	9.1	—	—	—	4.3	—	—	—	3.6	—
Cerf de Virginie (*Odocoileus virginianus*)	—	8.3	—	33.3	4.3	10.5	13.6	20.8	4.8	15.5
Raton Laveur (*Procyon lotor*)	—	—	—	—	—	—	9.1	—	2.4	—
Porc-épic (*Erethizon dorsatum*)	—	16.7	—	—	4.3	—	4.5	4.2	2.4	5.2
Campagnol des Champs (*Microtus pennsylvanicus*)	4.5	—	5.9	—	4.3	—	4.5	—	4.8	—
Souris Sylvestre (*Peromyscus maniculatus*)	4.5	—	5.9	—	8.7	—	4.5	—	6.0	—
Autres	—	—	11.8	—	17.4	—	4.5	—	8.3	—
Mammifères indéterminés	54.5	66.7	70.6	33.3	34.8	15.8	36.4	37.5	47.6	36.2
Oiseaux	9.1	8.3	5.9	—	4.3	5.3	22.7	—	10.7	3.4
Poulet domestique (*Gallus gallus*)	9.1	—	5.9	—	4.3	5.3	18.2	—	9.5	1.7
Autres	—	8.3	—	—	—	—	4.5	—	1.2	1.7
Végétaux	86.4	83.3	76.5	100.0	95.7	78.9	72.7	70.8	83.3	77.6
Pommier nain (*Malus pumila*)	4.5	—	—	—	13.0	—	22.7	4.2	10.7	1.7
Graminées cultivées	22.7	58.3	11.8	33.3	17.4	26.3	13.6	37.5	16.7	37.9
Débris végétaux divers	77.3	50.0	64.7	100.0	95.7	73.7	63.6	62.5	76.2	65.5
Litière forestière	50.0	8.3	35.3	—	43.5	31.6	22.7	8.3	38.1	15.5
Autres éléments[2]	40.9	100.0	29.4	66.7	17.4	36.8	54.5	50.0	35.7	56.9
Fragments osseux	31.8	50.0	11.8	—	13.0	31.6	22.7	33.3	20.2	34.5
Autres structures animales	22.7	50.0	11.8	—	13.0	10.5	13.6	8.3	15.5	17.2
Nourriture commerciale pour chiens	—	25.0	—	66.7	—	—	—	8.3	—	12.1
Déchets domestiques	—	50.0	11.8	—	—	15.8	9.1	33.3	4.8	29.3
Matière indéterminée	4.5	8.3	—	—	—	10.5	27.3	8.3	8.3	8.6

[1]Le mouton (*Ovis aries*), la chèvre (*Capra hircus*), et le cheval (*Equus caballus*).

[2]Regroupement des éléments importants; les fragments osseux de même que les autres structures animales servaient à l'identification des proies; les déchets domestiques incluaient souvent des restes de table et des éléments non-comestibles. La matière indéterminée provenait d'animaux ou de déchets domestiques.

remarqué de prédominance d'une espèce en particulier. Le Lièvre d'Amérique n'a été identifié que chez 6% des Coyotes. Des restes de Cerfs de Virginie, de Marmottes Communes (*Marmota monax*) et de Ratons Laveurs (*Procyon lotor*) apparaissent chacun dans moins de 5% des Coyotes. Représentant un faible pourcentage chez le Coyote, le Cerf de Virginie est apparu chez 16% des chiens analysés. En se basant sur les résultats obtenus, il ne semble pas que les Coyotes aient un effet sérieux sur les populations de cerfs de la

région tout au long de l'hiver. De plus, les premières captures près des quartiers d'hiver ne se font qu'à partir de février (Laurent Cloutier, Agent de Conservation, communication personnelle, 1979). Il faut se rappeler qu'à cette date, 20% des Cerfs peuvent périr dans un hiver moyen et que cette quantité peut s'élever à 40% au cours d'un hiver difficile (Potvin et Huot 1975).

Par contre, l'impact des chiens errants sur les Cerfs de Virginie en période de confinement est très important. A la fin de l'hiver les conditions de neige et de disette alimentaire rendent pénibles les déplacements des cerfs, en particulier ceux des femelles gravides. La libre circulation de groupes de chiens parmi les cerfs occasionne des poursuites et des dépenses d'énergie à la suite desquelles, les victimes survivent difficilement. L'analyse des contenus stomacaux de ces chiens a révélé la présence d'indices frais chez la plupart d'entre eux, ce que nous n'avons pas observé chez le Coyote. De leur côté, Perry et Giles (1971), Scott et Causey (1973), Denney (1974), Lachance (1975) et Thériault (1978) ont tous noté les effets négatifs de la présence de chiens dans les quartiers d'hiver des cerfs. De plus, maints témoins d'agression par des chiens errants sur des cerfs nous ont décrit les poursuites et les pertes infligées aux cheptels locaux. Cependant, il faut retenir que le piégeage des chiens s'est fait à l'intérieur des aires hivernales tandis que celui des Coyotes s'est effectué en périphérie, ce qui peut expliquer partiellement la différence des résultats.

Les petits mammifères dans leur ensemble ont été identifiés dans plus de 19% des Coyotes examinés, ce qui représente un élément assez stable de leur alimentation tout au long de l'année. Contrairement à d'autres études qui ne leur donnaient qu'une valeur saisonnière, nos résultats indiquent que le Campagnol des Champs (*Microtus pennsylvanicus*) et la Souris Sylvestre (*Peromyscus maniculatus*) sont des éléments stables de leur régime alimentaire, alors qu'apparaissent plus sporadiquement d'autres espèces de campagnols et de souris sauteuses.

La plupart des descriptions de contenus digestifs montrent que les oiseaux ne sont pas importants dans l'alimentation du Coyote. Des restes de poulet domestique (*Gallus gallus*) abandonnés dans des dépotoirs ou autour des fermes sont utilisés, particulièrement l'hiver, par 11% des Coyotes analysés. Des conclusions semblables ont d'ailleurs été suggérées par Murie (1935), Fichter et al. (1955), Gier (1968), Tiemeier (1975), Nellis et Keith (1976). Des indices de végétation ont été analysés dans plus de 83% des Coyotes et 78% des chiens examinés. Il s'agit le plus souvent de débris végétaux comme des aiguilles de conifères, des feuilles d'herbacées, d'écorce et de ramilles de plantes ligneuses, ce qui peut être une conséquence directe de la méthode de piégeage utilisée. Leur présence est importante chez les Coyotes capturés au printemps et à l'automne tandis qu'elle est plus uniforme tout au long de l'année pour le chien. Gier et al. (1978) et Niebauer et Rongstad (1977) ont décrit les qualités purgatives, vermicides, ou vitaminiques de certaines plantes. La présence de vergers abandonnés et de pommiers sauvages procure aux Coyotes de la région une source alimentaire surtout utilisée à l'automne et à l'hiver. Certaines substances plus ou moins comestibles ont été identifiées dans les analyses stomacales de 36% des Coyotes et 57% des chiens examinés. Parmi les déchets domestiques prélevés, nous avons trouvé du papier d'emballage, des pelures de fruits et de légumes, des restes de tables, des tissus et des objets métalliques ou de plastique.

Malgré le maximum d'objectivité accordé à l'analyse des résultats, nous demeurons conscients des limites de l'interprétation d'une partie de ceux-ci. La récolte de carcasses dépendait des sites de piégeage des trappeurs travaillant à leur solde, ainsi que de l'endroit où s'effectuaient les contrôles de prédateurs à proximité d'aires hivernales de Cerfs de Virginie et de fermes d'élevage. De plus, il est possible que dans certains cas, l'utilisation de carcasses d'animaux en guise d'appâts ait pû influencer les résultats. Notons cependant que plusieurs trappeurs utilisaient des appâts odoriférants et que d'autres nous ont mentionné la présence d'animaux déjà morts sur le site de trappage. Ces éléments, lorsque retrouvés dans les contenus digestifs, étaient enregistrés mais omis de l'analyse.

Il faut également tenir compte du fait qu'une bonne partie des carcasses provenant des programmes de répression de prédateurs a pu amener un biais dans les résultats à cause d'animaux "problèmes." Nous pensons tout de suite à la sur-représentation des restes d'animaux domestiques provenant de Coyotes trappés près des fermes et des dépotoirs et de la sur-représentation des restes de Cerfs de Virginie trouvés chez les chiens capturés ou abattus à proximité des quartiers d'hiver de cerfs.

Nous ne pouvons cependant nier deux grandes caractéristiques se dégageant de ce travail et venant appuyer les résultats de plusieurs auteurs du Canada et du nord-est des Etats-Unis dont les travaux se sont faits dans un contexte similaire au nôtre. Il s'agit de l'opportunisme du Coyote face aux sources de nourriture qui l'entourent et de l'impact des chiens errants sur les Cerfs de Virginie en période de confinement.

Remerciements

Cette étude a été réalisable grâce à un contrat de recherches et à des bourses d'études accordées par le Service Canadien de la Faune. Nous désirons remercier M. Serge Gonthier, chef de Service à l'Aménagement et à l'Exploitation de la Faune du Ministère du

Loisir, de la Chasse et de la Pêche, pour avoir coordonné la récolte de spécimens provenant du programme de contrôle des prédateurs.

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Reçu le 1 décembre 1979
Accepté le 20 octobre 1980

Variation in Frequencies of Pelvic Phenotypes of the Brook Stickleback, *Culaea inconstans*, in Redwater Drainage, Alberta[1]

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Reist, James D. 1981. Variation in frequencies of pelvic phenotypes of the Brook Stickleback, *Culaea inconstans*, in Redwater drainage, Alberta. Canadian Field-Naturalist 95(2): 178–182.

In Brook Stickleback, *Culaea inconstans*, geographical variation in relative frequencies of pelvic phenotypes was noted especially between lotic and lentic environments. In the primary study area, Wakomao Lake in central Alberta, no association of any pelvic phenotype with grossly defined habitats was evident. The relative frequencies of all pelvic phenotypes were stable from 1971 to 1977; however, the frequency of the form without the pelvis and spines decreased over winter. Frequencies of the subsequent generation returned to prewinter values, thus suggesting some cyclical seasonal variation. Causative agents for the maintenance of the frequencies were sought. The observed frequencies are not due to sampling biases, rather the most likely cause is some selective agent(s). Mass die-off of sticklebacks during midsummer oxygen depletion was not differential. Other studies implicate predation by a variety of piscivores as a selective agent.

Key Words: *Culaea inconstans*, Brook Stickleback; pelvic variation, spatial and temporal frequency.

Brook Stickleback, *Culaea inconstans*, show clines in lengths of pelvic and dorsal spines (Nelson 1969). Also, a high proportion of individuals lack the pelvic skeleton and associated pelvic spines in numerous populations in midcentral Alberta and Saskatchewan (Nelson 1969, 1977; Nelson and Atton 1971; Nelson and Paetz 1974).

Four pelvic states are observed in variable populations of *Culaea*: complete presence — *with*(s), complete absence —*without*(s), intermediate with a single spine — *spined*, and intermediate with only an internal bony plate —*spineless* (see figures in Nelson 1969, 1977). This variation has at least a partial genetic basis (Nelson 1977).

Extent and range of variation of the phenomenon has been described (Nelson 1977; Nelson and Atton 1971), but adequate, in-depth examination is lacking for the variation over space and time, both within single sites and between sites in close spatial proximity. In this study I have described geographical, habitat, and temporal variation of frequencies of pelvic phenotypes in the Redwater drainage of Alberta, as background to investigations into the evolutionary significance of the phenomenon (Reist 1980 a, b).

Additionally, some aspects of the explanation for such phenotypic variation are investigated. Such explanations may be grouped into three classes: (1) variation might be due to methodological problems —sampling biases or errors of assignment to phenotypic classes; (2) historical canalization of phenotypic frequencies might result in the observed variation, that is, the present situation might be due to stochastic influences such as drift or immigration, or it may be a transient situation proceeding to future fixation of one phenotype; (3) finally, variation might be due to selective force(s) qualitatively or quantitatively varying over space and time, resulting in a balanced system. Evidence is presented which seems to refute the first two of these explanations. One aspect of the third explanation is tested in additional studies (Reist 1980a, b) which investigated predation as a potential selective force in more detail.

Study Area

The Redwater river system (Figure 1), a collection of small lakes and rivers about 80 km north of Edmonton, Alberta, is a tributary to the North Saskatchewan River. The lakes tend to be shallow and eutrophic, and the creeks are narrow and meandering.

Land surrounding the bodies of water is flat, and extensive marshes, of either aquatic macrophytes or drowned bogs of Black Spruce (*Picea mariana*) – willow (*Salix* sp.), are typical. Extensive beaver activity and large numbers of deadfall blockages on the creeks likely restrict fish movements, especially during winter or the drier periods of the year.

The major study area, Wakomao Lake (54°09′N, 113°32′W), is a small (about 325 ha) lake most proximate to the North Saskatchewan River. Maximum depth is 2.5 m. Most of the shoreline is marshy with extensive beds of emergent macrophytes, but the windward southeast corner is sandy beach. Large

[1]Based upon a thesis submitted to the University of Alberta in partial fulfillment of the requirements for the degree of Master of Science.

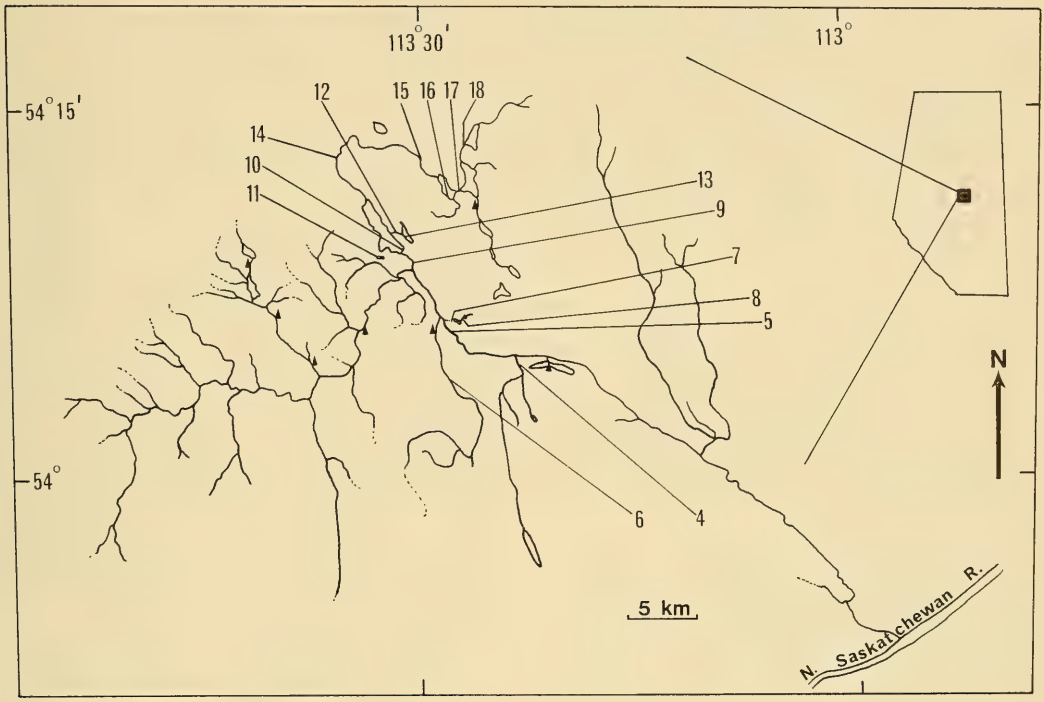

FIGURE 1. The study area, Redwater River system, Alberta. Numbers refer to collection sites (see Table 1 for site names); and (▲), areas sampled but where no sticklebacks were found. The major study area was Wakomao Lake (Number 10).

amounts of submerged and floating vegetation are present throughout the lake during the summer. Wakomao Lake is subject to light recreational pressure — angling and boating. It was also the subject of an abortive fisheries management program in 1955. Four species of fish were found in Wakomao Lake during the study: *Culaea inconstans, Pimephales promelas* (Fathead Minnow), *Catostomus commersoni* (White Sucker), and *Esox lucius* (Northern Pike).

Materials and Methods

All collections of fishes were made in water depths of 0–1.5 m by the most convenient method, usually dip net or bag-seine. Sampling was conducted at each location by methods which would lessen potential biased collection of phenotypes. The samples were immediately preserved in 10% formalin.

Pelvic phenotypes are easily scored by running a sharp probe over the belly, although some individuals of the spineless phenotype may incorrectly be classed as *withouts*; however, the pelvic remnant of *spineless* individuals is usually large enough to permit unambiguous identification. Pelvic development occurs between 13 and 21 mm standard length (SL, the distance from tip of the snout to end of the fleshy lobe of the caudal peduncle). The first structures to appear are the pelvic spines (Nelson and Atton 1971). All fish less than 21 mm SL were examined under a low-power dissecting microscope. Fish less than 15 mm SL were considered unassignable and left out of statistical considerations.

To investigate variation in phenotypic frequencies, I designated eight habitats in Wakomao Lake using predominant vegetation type, time of year, and spatial position. Association of any phenotype with these was tested using multiple samples obtained from each.

Samples taken at the appropriate times were compared to establish change of frequency with season, age, and longer periods of time. In the 1977 cohort, age-classes were defined using standard length as the criterion.

Collection from a 5 × 10 m quadrat of the beach of Wakomao Lake permitted investigation of collection biases. This area was sequentially collected by bag-seine, dip net, and electrofisher (Smith-Root Inc. Type VII). Baited minnow traps set in other areas of the lake constituted a fourth collection method.

Collection at a single site (No. 8, Figure 1) in early May fortuitously resulted in a sample of "naturally" dead fish and a sample of "live" fish thus permitting

the test of a selective death hypothesis. Cause of mortality was not identified, but the fish were subject to extreme crowding in a small creek so that oxygen depletion may have been a factor.

Many sites were visited several times; thus, the sample sizes represent composite samples. All multiple samples were tested for heterogeneity (Sokal and Rohlf 1969) and then combined, because none were heterogeneous. Statistical comparison of samples was by row by column chi-square tests.

Results

Moderate amounts of variation in phenotypic frequencies are evident among the 15 sites (Table 1). The greatest deviations from expected frequencies are sites 6, 8, 13, 15, and 16. Frequencies in remaining areas are relatively consistent at 70% *with*, 5% intermediates (*spined* and *spineless*), and 25% *without*.

The average frequencies for collections from creeks (sites 4, 5, 6, 8, 9, 12, 14, 15, 17, 18) are 72.8% *with*, 5.0% intermediates, and 22.2% *withouts*. Average frequencies for collections from lake environments (sites 7, 10, 11, 13, 16) are 70.6% *with*, 4.4% intermediate, and 25.0% *without*. The differences are statistically significant ($P < 0.05$).

Association of any phenotype with a particular habitat is not evident (Table 2, $P > 0.05$). No sticklebacks were visually sighted or taken in surface minnow traps set for 270 trap-hours. The gross nature of habitat definition and collection does not preclude microhabitat association.

Collections from Wakomao Lake in 1971 show phenotypic frequencies (71.0% *with*, 4.4% intermediate, and 24.6% *without*, $N = 284$) similar to those of 1977.

A significant decrease in frequency of intermediate and *without* phenotypes with a concomitant increase in frequency of *withs* was observed over winter (Table 3, $P < 0.025$). Relative frequencies tended to be restored to prewinter values in the next sample from 1977 which contained scoreable young from that year (Table 3). Within the year-class from 1977, there was a tendency for increase in frequency of *withs* and intermediates and a decrease in *without* frequencies, although this is not significant (Table 4, $P > 0.05$).

On the collected quadrat, no method of collection preferentially selected for any particular phenotype (Table 5, $P = 0.8$). Minnow trap samples from other areas of the lake also did not preferentially select for a phenotype ($P = 0.4$). The phenotypic frequency in the sample of fish presumed to have died of oxygen starvation did not differ from that of the sample still living when collected (Table 6, $P = 0.6$), implying nonselective death of pelvic phenotypes.

Discussion

Sites that contribute to significant geographical variation in frequencies differ in physicochemical and biotic features not quantified in this study. For example, site 6 is a spring-fed creek with water temperatures consistently below those from other sites, and site 8 contains little or no aquatic vegetation. These findings

TABLE 1—Frequencies of pelvic phenotypes of Brook Stickleback in the Redwater River system. Map numbers refer to locations on Figure 1. Samples with less than 50 individuals are not included. The intermediate phenotypes were combined for calculating the chi-square statistic ($P < 0.05$)

Map number	Site name	Number of phenotypes (%)				N	Number of samples
		With	*Spined*	*Spineless*	*Without*		
4	Outflow from Halfmoon Lake	93(70.5)	4(3.0)	4(3.0)	31(23.5)	132	1
5	Redwater River	402(69.8)	16(2.8)	18(3.1)	140(24.3)	576	4
6	Fairydell Creek	72(68.6)	4(3.8)	6(5.5)	23(21.9)	105	1
7	Overflow from unnamed lake	51(79.7)	1(1.6)	1(1.6)	11(17.2)	64	1
8	Beaver Pond Creek	617(76.5)	13(1.6)	21(2.6)	155(19.2)	806	1
9	Creek south of Wakomao Lake	190(70.1)	9(3.3)	8(2.9)	64(23.6)	271	1
10	Wakomao Lake	1526(70.6)	73(3.4)	31(1.4)	531(24.6)	2161	15
11	Slough south of Wakomao Lake	89(70.1)	1(0.8)	4(3.1)	33(26.0)	127	1
12	Halfway Creek	105(72.4)	4(2.7)	3(2.1)	33(22.7)	145	1
13	Halfway Lake	71(63.4)	1(0.9)	1(0.9)	39(34.8)	112	1
14	Wakomao Creek	322(70.9)	9(2.0)	10(2.1)	106(23.7)	447	3
15	Wakomao Creek	247(73.3)	1(0.3)	6(1.8)	83(24.6)	337	3
16	West Bridges Lake	205(71.2)	4(1.4)	4(1.4)	75(26.0)	288	3
17	Bridges Creek	205(72.4)	9(3.2)	7(2.5)	62(21.9)	283	2
18	Duggans Creek	226(74.1)	11(3.6)	7(2.3)	61(20.0)	305	2

TABLE 2—Phenotypic frequency of Brook Stickleback by habitat within Wakomao Lake

Habitat type	Number of phenotypes (%)				N	Number of samples
	With	*Spined*	*Spineless*	*Without*		
1. Burreed-*Typha* shoreline	111(65.3)	7(4.1)	7(4.1)	45(26.5)	170	2
2. *Scirpus* shoreline	432(74.6)	19(3.3)	9(1.5)	119(20.5)	579	4
3. *Myriophyllum-Lemna:* washed on shore submerged	325(69.1)	18(3.8)	3(0.6)	124(26.4)	470	2
4. *Myriophyllum*: rooted on shore submerged	207(70.2)	8(2.7)	2(0.7)	78(26.4)	295	2
5. Open sand beach less than 5% cover vegetation, *Culaea* here May–June only	236(68.2)	10(2.9)	8(2.3)	92(26.6)	346	2
6. Submerged algal mats (*Cladophora* sp. — May–June only)	83(67.5)	6(4.9)	2(1.6)	32(26.0)	123	1
7. Offshore rooted *Myriophyllum–Potamogeton*	132(74.1)	5(2.8)	0(0.0)	41(23.0)	178	2
8. Open, unvegetated water[a]	0(00.0)	0(0.0)	0(0.0)	0(00.0)	0	2
Pooled	1526(70.6)	73(3.4)	31(1.4)	531(24.6)	2161	

[a]Not included in computation of chi-square statistic.

agree with a general correlation of variation in phenotypic frequencies with characteristics of the water body. Nelson and Atton (1971) suggested that *withouts* tend to occur in lakes lacking outlets and those subjected to management practices.

Nelson (1969) suggested lack of choice of prey items available to a predator, thus inevitable predation despite deterrents such as spines may make it favorable for the loss of minimally useful structures such as the pelvic spines. The result would be a more streamlined and lighter animal, perhaps capable of quicker acceleration away from predators (Nelson 1969). If truly an advantage such streamlining should also be favorable in flowing water presumably as a result of decreased hydrodynamic drag (assuming the predator/prey situation is equivalent). The significantly lower frequency of *withouts* in creeks mitigates against such a difference; however, care is warranted in interpreting

TABLE 3—Change in phenotypic frequency of Brook Stickleback overwinter (1976 juveniles to 1977 adults) in Wakomao Lake

Time	Number of Phenotypes (%)			N
	With	Intermediate	*Without*	
June 1976	495(68.6)	70(9.8)	161(22.2)	726
May 1977	144(77.1)	7(3.7)	36(19.1)	188
July 1977	563(72.5)	43(5.5)	170(21.9)	776

TABLE 4—Change in phenotypic frequency of Brook Stickleback with age in Wakamao Lake (four collections, one each from July, August, September, October 1977)

Standard length (= age) group	Number of phenotypes (%)			N
	With	Intermediate	*Without*	
15–29.9 mm	315(75.0)	17(4.1)	88(20.9)	420
30–39.9 mm	324(72.5)	31(6.9)	92(20.6)	447
40+ mm	106(77.9)	12(8.8)	18(13.2)	136

TABLE 5—Phenotypic frequencies of Brook Stickleback from different collecting methods in Wakomao Lake

Method	Number of phenotypes (%)			N
	With	Intermediate	*Without*	
Bag-seine	251(74.0)	17(5.0)	71(21.0)	339
Dip net	152(68.2)	14(6.3)	57(25.5)	223
Electrofisher	160(74.8)	12(5.6)	42(19.6)	214
Total	563(72.5)	43(5.5)	170(22.0)	776
Minnow trap	70(68.0)	9(8.7)	24(23.3)	103

TABLE 6—Phenotypic frequency of Brook Stickleback in collection Number 8, Beaver Pond Creek, between "live" and "dead" fish

State of fish	Number of phenotypes (%)			N
	With	Intermediate	*Without*	
Live	607(75.6)	43(5.3)	153(19.1)	803
Dead	231(78.6)	14(4.8)	49(16.6)	294

these data because the creeks generally are not rapidly flowing.

Lack of association of any phenotypic class with a particular habitat indicates that differential usage or partitioning of the environment does not occur, at least at the gross level considered. Predators such as Northern Pike commonly associate with cover vegetation which is not too dense (Christiansen 1976). If association was habitat specific, such predators would not be attempting to prey upon a frequency of pelvic phenotypes different from that in the entire lake. Therefore the discrepancies found by Reist (1980a), between phenotypic frequencies in the lake and in pike stomachs, are not due to differential availability of the pelvic phenotypes.

The nonsignificant change in frequencies between 1971 and 1977 suggests the frequencies are stable thus mitigating against a transient evolutionary event; however, the short duration precludes a firm conclusion. Variation in frequency of *withouts* with season suggests that a seasonal, environmental parameter may be a cause of selective elimination of the phenotype. Such cyclical selection has been advanced as a potential factor maintaining polymorphisms (Maynard Smith 1970). Similarly, the tendency for decrease in frequency of *withouts* with age suggests they may have some disadvantage relative to *withs*.

Methodological biases or scoring are not responsible for observed variation in phenotypic frequencies; thus, a biological explanation for temporal and geographic variation is most likely. Few data are available on historical influences, such as genetic drift or gene flow, which may significantly affect frequencies prior to the action of selective forces. Accordingly, the most productive area to investigate for factors contributing to the maintenance of the observed phenotypic frequencies is one involving selective explanations. Indication of a selective disadvantage of *withouts* has been presented, that is, decrease in frequency over winter and with age, but a specific selective agent has not been identified. The lack of selectivity for any phenotype in the sample of "naturally" dead fish indicates not all environmental agents are selective forces involved in maintaining this variation.

Other studies have investigated one potential aspect of selection, predation by vertebrate and invertebrate piscivores (Reist 1980a, b). These studies suggest a relative disadvantage for the *withs* during predation by large Northern Pike and by *Dytiscus* larvae (Dytiscidae, water beetles). This disadvantage seems to be the result of behavioral rather than morphological differences between the *with* and *without* phenotypes. This disadvantage of the *with* phenotype could potentially be balanced by the aforementioned disadvantage of the *without* phenotype. Thus the frequency of phenotypes at any one point in time or space probably represents a balance between opposing selective forces that tend to eliminate the least fit phenotype. Qualitative or quantitative variation of the selective regime, primarily predators, would result in different stable equilibria of the frequencies thus explaining the diversity of frequencies observed (Nelson 1969, 1977; this study).

These studies are insufficient to explain all aspects of this phenotypic variation, thus other predators or other selective forces such as differential reproductive success (for example, fecundity, assortative mating) must be considered.

Acknowledgments

I thank E. J. Crossman, B. G. Naylor, and J. S. Nelson for valuable comment on early versions of the manuscript. J. S. Nelson, my thesis supervisor, provided welcome guidance and encouragement throughout the study. R. Foote, L. Reist, and T. van Meer assisted in the field collections. Funding for the study was provided by National Research Council of Canada operating grant A5457 (to JSN) and a National Research Council of Canada postgraduate scholarship.

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Received 28 June 1980
Accepted 21 October 1980

Feeding and Social Behavior of Some Migrant Shorebirds in Southern Manitoba

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Wishart, Richard A., Patrick J. Caldwell, and Spencer G. Sealy. 1981. Feeding and social behavior of some migrant shorebirds in southern Manitoba. Canadian Field-Naturalist 95(2): 183–185.

The foraging and social behavior of spring migrant shorebirds were observed as they fed on earthworms in a ploughed field in southern Manitoba. Black-bellied Plovers (*Pluvialis squatarola*) and American Golden Plovers (*P. dominica*) foraged by visually locating prey, interspersed with bursts of walking and probing. A greater proportion of feeding attempts by Black-bellied Plovers were successful compared to those of American Golden Plovers, but the latter made more attempts and hence obtained about the same number of prey items per unit time of foraging. Ruddy Turnstones (*Arenaria interpres*) had a lower percentage of successful feeding attempts than plovers but obtained more than twice the number of food items per minute. Social interactions in the flocks, particularly involving Black-bellied Plovers, led to a dominance hierarchy that was related directly to body size. Bill and leg lengths may also have affected the ability of birds to capture prey and influenced their feeding success rates and strategies.

Key Words: Black-bellied Plover (*Pluvialis squatarola*), American Golden Plover (*P. dominica*), Ruddy Turnstone (*Arenaria interpres*), foraging, dominance, migration, Manitoba.

Shorebirds often associate in mixed-species flocks while feeding. Such assemblages during migration offer opportunities to compare foraging strategies and possible competition among closely related species that may not come into contact on breeding or wintering grounds (Recher and Recher 1969; Goss-Custard 1970; Baker and Baker 1973; Burger et al. 1979). In this study, we compared the feeding behavior of Black-bellied Plovers (blackbellies) (*Pluvialis squatarola*), American Golden Plovers (goldens) (*P. dominica*), and Ruddy Turnstones (*Arenaria interpres*) that fed in a mixed flock in a ploughed field in southern Manitoba during spring migration. We documented social interactions within the flock which also included Ring-billed Gulls (*Larus delawarensis*) and Least Sandpipers (*Calidris minutilla*).

Study Area and Methods

The birds were concentrated on a wet ploughed field 0.6 km², 16 km north of Portage la Prairie, Manitoba (50° 06′N, 98° 16′W). Other such fields, used for growing cereal grains, surrounded the area.

We made 4 h of detailed observations on 27 and 28 May 1975, using a 20–45 times spotting scope from a stationary vehicle. Birds were 30–100 m from the observers. Before each observation period we counted the number of each species present. Behavior of a feeding individual was watched for as long as possible (1.5–14 min), and feeding attempts and their success were described into a tape recorder. We could see birds pulling up and mandibulating prey when successful. We estimated the distance plovers moved after successive feeding attempts in relation to the known length of the bird, and counted the number of pauses between feeding attempts. Intra- and inter-specific interactions were also described.

We measured earthworm (Oligochaeta) densities on 27 May, using Raw's (1959) formaldehyde expellant techique. Quadrats, each 0.8 m², were sampled in the field used by birds and in an adjacent unused field. The pH of a soil sample from the top 4 cm in each field was measured, and the soil oven-dried to estimate its moisture content.

Results

Shorebirds were seen at the field from 25 May until 29 May, but counts were made only on 27 and 28 May (Table 1). Soil from this field had a moisture content of 31.1% compared to 8.7% for the unused field. The pH of these fields was similar (6.7 and 6.9, respectively), but earthworm (*Aporectodea* sp.) density differed markedly (77.1 worms/m² and zero, respectively). Other soil invertebrates sampled (e.g.,

TABLE 1—Number of birds[a] counted on study area on 27 and 28 May 1975

Date	Time	RB	BB	GP	RT	LS
27 May	A.M.	0	125	61	3	0
	P.M.	0	249	90	21	36
28 May	A.M.	0	90	21	0	0
	P.M.	20	168	92	30	17

[a]RB, Ring-billed Gull; BB, Black-bellied Plover; GP, American Golden Plover; RT, Ruddy Turnstone; LS, Least Sandpiper.

Araneae, Acarina, and Chilopoda) were not common in either field.

Six goldens were observed for 44.5 min (range of 4–12 min each), five blackbellies for 43 min (5–14 min), and two turnstones for 7.5 min (1.5–6 min). The remaining 145 min of observation were spent watching the flock as a whole and recording social interactions.

Birds moved about the field probing in the soil or pecking at its surface for food. Most food items obtained were earthworms, which we could see being pulled from their burrows or as they dangled from the birds' bills.

Blackbellies and goldens typically moved with head erect in rapid bursts of walking, interspersed with pauses when they often looked down and probed or pecked once or several times for food. Both species moved similar distances (with means ± SD for blackbellies = 1.3 ± 1.0 m, n = 52 vs. goldens = 1.1 ± 1.1 m, n = 105) and paused a similar number of times between feeding attempts (blackbellies = 3.3 ± 2.3, n = 52 vs. goldens = 3.2 ± 2.3, n = 105) whether after a successful or unsuccessful feeding attempt ($P > 0.05$, t-test) (thus data above are pooled).

Blackbellies made slightly fewer feeding attempts per minute of foraging than goldens (2.9 ± 1.1, n = 5 birds vs. 3.8 ± 1.3, n = 6) (P = 0.17, Mann-Whitney U test), but a greater proportion of these were successful (40.4 ± 9.1% vs. 23.9 ± 15.4%) ($P < 0.05$). Thus blackbellies obtained slightly more earthworms per minute of foraging (1.1 ± 0.3 vs. 0.8 ± 0.3) (P = 0.06).

In contrast, two Ruddy Turnstones we watched averaged 42.7 feeding attempts/min (range 25.3–60.0), although only 7.4% (5.6–9.2) of these were successful. They secured an average of 2.8 worms/min (2.3–3.3), more than double the rate for either plover ($P < 0.05$). Unlike the plovers, turnstones moved in rapid bursts with tail up and bill down, almost constantly pecking and probing in the soil for food.

Although none of the birds in the flock appeared to be paired and none was courting, aggressive interactions between individuals often occurred (Table 2). In 43 min five blackbellies were involved in 20 encounters (0.47/min) whereas in 44.5 min six goldens were in 10 encounters (0.22/min).

Overall, 57.3% (n = 110) of aggressive encounters were between conspecifics. Fifty-five percent of all encounters resulted in one bird chasing another, usually for less than 3 m. The remainder involved one bird supplanting another without pursuit. No fighting was observed but many intraspecific encounters involved displays. Both blackbellies and turnstones gave chattering calls during some encounters.

An interspecific dominance hierarchy, related directly to body size, existed in the flock (Table 2).

TABLE 2—Aggressive encounters among birds[a], arranged by size and position in the dominance hierarchy

	Winner					
Loser	RB	BB	GP	RT	LS	Total
RB	0	0	0	0	0	0
BB	15	57	0	1	0	73
GP	0	17	3	0	0	20
RT	4	4	2	3	0	13
LS	0	3	1	0	0	4
Total	19	81	6	4	0	110

[a]RB, Ring-billed Gull; BB, Black-bellied Plover; GP, American Golden Plover; RT, Ruddy Turnstone; LS, Least Sandpiper.

Ninety-nine percent of interspecific encounters were won by a larger species. Only once did a turnstone (smaller) supplant a blackbelly (larger).

Several encounters may have been attempts at pirating food. One turnstone grabbed an earthworm as it dangled from the bill of a blackbelly. Ring-billed Gulls occasionally chased blackbellies up to 90 m in flight, presumably trying to steal their prey (see Payne and Howe 1976; Kallander 1977). However, no successful kleptoparasitism was observed. Gulls were successful in securing earthworms independently, but their individual feeding rates were not timed.

Discussion

The birds observed in this study exploited a locally abundant food source. Others have also noted migrant plovers using agricultural fields and feeding on earthworms (Bent 1929; Burton 1974; Payne and Howe 1976), a nutritious food (Kallander 1977). We do not know if earthworms are available at this field every spring, nor if it is traditionally used by shorebirds, as are certain coastal areas and inland fields on both the breeding and wintering grounds (Bengtson et al. 1978; Fuller and Youngman 1979).

The plovers fed similarly but the blackbellies obtained more earthworms/min. Blackbellies were dominant over goldens, and may have been able to usurp superior feeding sites. Goldens, by avoiding encounters with blackbellies (which they always lost), may have spent less of their feeding time in 'superior' areas. Like the American Robin (*Turdus migratorius*) (Heppner 1965), most land-foraging shorebirds probably rely on sight to detect earthworms. Blackbellies have slightly longer legs (4.7%) and much longer bills (25%) (Godfrey 1966) than goldens, and so may be able to observe potential prey at a greater distance, move faster, and be more successful at capturing it.

Foraging by turnstones seemed to be energetically more costly (faster rate of pecking and movement)

than that used by plovers, although they obtained more food items per foraging minute. Turnstones have much shorter legs than either plover (40%) (Godfrey 1966) and may less often observe prey from a distance. Turnstones seemed to take observable prey when available but supplemented this by exposing food that would have been missed by relying on visual cues only (plover method). The latter part of their diet is, at least momentarily, unavailable to plovers, and this may allow turnstones to reduce competition with the more dominant species. Although food intake rates varied, without measuring time budgets and prey sizes taken, it is not yet possible to compare net energy gains among the species.

Most social interactions were intraspecific, as found by Recher and Recher (1969) and Burger et al. (1979). Dominance in the hierarchy was related directly to body size, as noted also by Bailey and Batt (1974), Morse (1974), and Burger et al. (1979). Thus, larger birds have an advantage in competing, particularly if resources are limited or patchy. However, if they are relying on the same food, larger individuals require more items and so must expend more effort in meeting their nutrient needs.

Stinson (1977) saw little intraspecific aggression in a wintering flock of blackbellies, and believed that avoidance was responsible for the spaced-out distribution that he observed. Strauch and Abele (1979) observed a similar relationship for other wintering plovers. However, in our study the birds spent much time in aggressive encounters, perhaps owing to differences in food distribution or flock density. Where food is aggregated or bird numbers are large in relation to the available feeding space, encounter rate and thus competition increase (see Stinson 1980). Burger et al. (1979) and Mallory and Schneider (1979) found similar relationships between rates of aggressive encounters and habitat conditions with other shorebird species. Unlike wintering shorebirds those we observed were presumably depositing fat to meet the demands of migration and reproduction. This is likely another reason why we saw more competition than did other observers.

Acknowledgments

We thank C. M. Savage and T. G. Neraasen for helping to collect data and J. W. Reynolds for identifying the earthworms. While involved in this and other studies we were funded by the Delta Waterfowl Research Station, Canadian Wildlife Service, Universities of Manitoba and Kansas State, and grant A9556 (to S.G.S.) of the Natural Science and Engineering Research Council of Canada. G. W. Page and another reviewer offered helpful advice.

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Received 26 May 1980
Accepted 6 October 1980

Distribution, Growth, and Foods of Arctic Cod (*Boreogadus saida*) in the Bering, Chukchi, and Beaufort Seas

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Lowry, Lloyd F., and Kathryn J. Frost. 1981. Distribution, growth, and foods of Arctic Cod (*Boreogadus saida*) in the Bering, Chukchi, and Beaufort seas. Canadian Field-Naturalist 95(2): 186–191.

Arctic Cod (*Boreogadus saida*) are abundant and ecologically important in arctic and subarctic marine ecosystems. Based on otter trawl collections made in the northern Bering and northeastern Chukchi and Beaufort seas, Arctic Cod were most abundant in the northeastern Chukchi and western Beaufort seas. There was no relationship between water depth and abundance; however, in the Chukchi and Beaufort seas small fishes were more common in water less than 100 m deep. Annual growth increments appear to be quite variable which complicates interpretation of size at age data. Arctic Cod less than 4 yr were larger at a given age in the Bering Sea. In the Bering Sea gammarid amphipods were the main food with mysids, shrimps, and hyperiid amphipods also eaten. In the northeastern Chukchi and Beaufort seas, calanoid copepods were by far the predominant prey with other crustaceans eaten much less frequently. Arctic Cod appear to be a very adaptable species which may explain their overwhelming success in Arctic marine waters.

Key Words: *Boreogadus saida,* Arctic Cod, distribution, foods, growth, abundance.

Three species of gadid fishes are abundant and ecologically important in marine waters of western and northern Alaska. Walleye Pollock (*Theragra chalcogramma*) is the most abundant finfish in southern and central Bering Sea (Bakkala, R. G., and G. B. Smith 1978. Demersal fish resources of the eastern Bering Sea: spring 1976. Northwest and Alaska Fisheries Center Processed Report. 233 pp.). Saffron Cod (*Eleginus gracilis*) is the most abundant species during summer months in the northern Bering and southern Chukchi seas (Wolotira, R. J., J. M. Sample, and M. Morin, Jr. 1977. Demersal fish and shellfish resources of Norton Sound, the southeastern Chukchi Sea and adjacent waters in the baseline year 1976. Northwest and Alaska Fisheries Center Processed Report. 292 pp.). In truly arctic waters and in winter months in the northern Bering and southern Chukchi seas, Arctic Cod (*Boreogadus saida*) is by far the most abundant forage fish species (Moskalenko 1964; Ponomarenko 1968). In combination these species provide a large portion of the annual nutrition of most species of marine mammals in these areas (Klumov 1937; Tomilin 1957; Johnson et al. 1966; Lowry et al. 1979). Generally, a more diverse assemblage of forage fish species are available and utilized in the Bering than in the Chukchi and Beaufort seas. In the Beaufort Sea, Arctic Cod is virtually the only widely distributed and abundant forage fish species.

The biology of Walleye Pollock has been studied in detail because of its importance in commercial bottomfish catches. Less is known of the biology of Arctic and Saffron Cods although there have been several significant studies of Arctic Cod in the Barents Sea and in Siberian waters (Moskalenko 1964; Baranenkova et al. 1966; Hognestad 1968; Ponomarenko 1968; Rass 1968). In light of their ecological importance and pending developments which may affect marine systems, detailed information on the biology of Arctic and Saffron Cod in Alaskan waters is greatly needed. In this paper we present observations on the biology of Arctic Cod caught by bottom trawls in the Bering, Chukchi, and Beaufort seas.

Methods and Materials

Tows were made using a 5.8-m (19-ft) headrope semiballoon otter trawl with 3.2-cm (1.25-in.) stretch mesh webbing in the body and 0.6-cm (0.25-in.) stretch mesh liner in the cod end. In the northeastern Chukchi and Beaufort seas, 33 successful tows (10 min bottom time) were made during the period 2 August to 3 September 1977. This set of tows was broken down by three subareas: northeastern Chukchi Sea (west of Point Barrow), 10 tows; western Beaufort Sea (Point Barrow to Prudhoe Bay), 8 tows; central Beaufort Sea (east of Prudhoe Bay), 15 tows. In the northern Bering Sea 32 tows (20 min bottom time) were made between 27 May and 10 June 1978 (Figure 1). Arctic Cod were sorted from other components of the trawl catches. Fishes caught in the Bering Sea tows were immediately enumerated, weighed, and measured (fork length to the nearest millimetre), and otoliths and stomachs were removed. Stomachs were split open and the contents were washed into a petri dish where prey items were identified and separated by taxon. Components of the stomach contents were ranked according to their relative abundance, i.e., the most abundant prey was given a rank of 1, the second most abundant a rank of 2, and so on. Arctic Cod

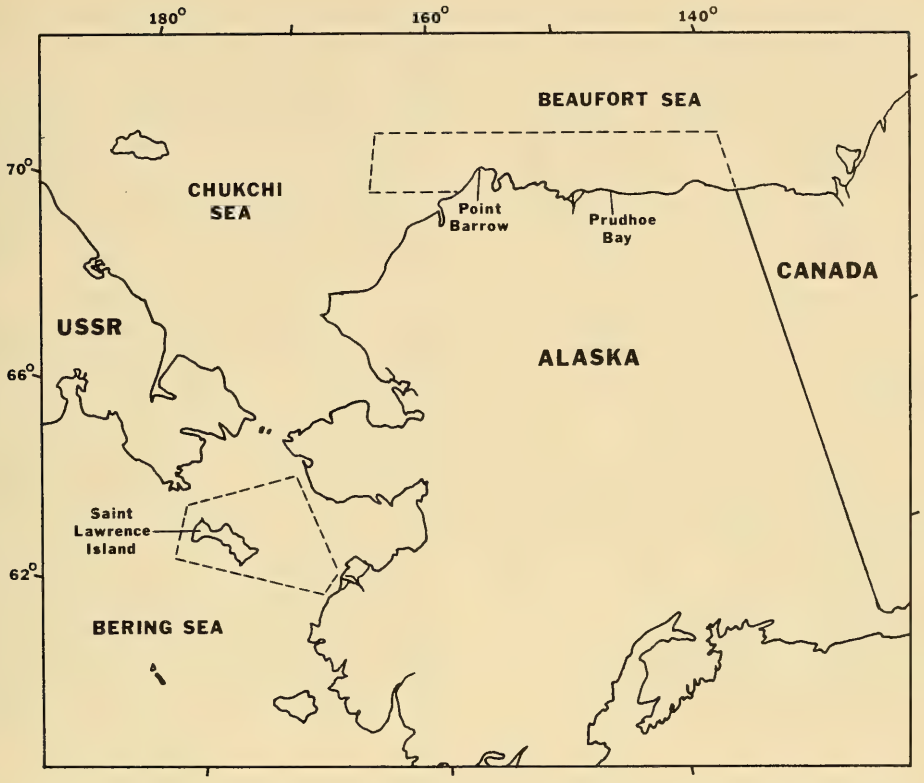

FIGURE 1. Map of Alaska showing the two regions (broken lines) where Arctic Cod were collected.

caught in the Chukchi and Beaufort seas were treated similarly except that fishes were preserved by injection of 10% formalin into the abdominal cavity and immersion in a 10% formalin–seawater solution. Fishes were weighed and measured and stomach contents were examined 3–6 wk later. For presentation of results, lengths of preserved fishes were corrected for shrinkage resulting from preservation by increasing measured length by 2.1% (Lowry and Frost, unpublished data based on 25 Arctic Cod measured before and after 3 wk preservation in 10% formalin). Ages of fishes were determined using annular rings in otoliths. The medial surface of each otolith was ground on a fine stone. The otoliths were then immersed in xylene and the rings counted using a binocular microscope and reflected light. In some otoliths, rings were more easily observed by examining a cross section. In such cases the otolith was broken transversely through the middle and the broken surface was polished, then examined under the microscope.

Results and Discussion

The overall distribution of Arctic Cod generally coincides with that of seasonal and multiyear sea ice (Andriyashev 1954; Ponomarenko 1968). With the exception of three tows in the Bering Sea, all our tows were made in or very near pack ice. In the Bering Sea, Arctic Cod were caught in three tows south of the ice; the most southerly occurrence was at 61°33′0″N, 174°30′48″W, about 300 km from the ice on 27 May 1978. This area had been ice-covered 3 wk previously. Arctic Cod are still widely distributed although not particularly abundant in the northern Bering Sea in late summer, long after the ice has gone (Wolotira et al. 1977, *op. cit.*).

In our samples, Arctic Cod were most widespread and abundant in the northeastern Chukchi and western Beaufort seas and least abundant in the northern Bering and central Beaufort seas (Table 1). This is perhaps due to many Arctic Cod from the northern Bering and southern Chukchi seas moving north with

TABLE 1—Occurrence and relative abundance of Arctic Cod in the study areas

Area	Number of tows	Tows with Arctic Cod (%)	No. of Arctic Cod per tow, mean (range)
Northern Bering Sea[1]	32	56.2	3.3 (0–37)
Northeastern Chukchi Sea[2]	10	100.0	10.3 (1–26)
Western Beaufort Sea[2]	8	100.0	7.8 (2–24)
Central Beaufort Sea[2]	15	66.7	1.9 (0–11)

[1]Bottom time 20 min.
[2]Bottom time 10 min.

the receding ice edge, and suggests that they do not penetrate far to the east in the Beaufort Sea. There was no obvious relationship between depth of water and catches of Arctic Cod. In the northeastern Chukchi and Beaufort seas, 26 tows were made in water 40–100 m deep while 8 tows were in waters 101–400 m deep. The mean number of Arctic Cod caught was 5.7 in shallow tows (range 0–26) and 5.5 in deeper tows (range 0–24). In the Bering Sea most tows were in waters less than 50 m deep and again there was no obvious relationship between abundance and water depth.

We casually examined the gonads of the larger Arctic Cod caught; in both sexes these were small, ranging in weight from 0.1 to 0.9 g, usually less than 3% of the total body weight of the fish. That is consistent with previous observations that gonadal development begins in September in preparation for spawning during winter months (Moskalenko 1964).

Fishes caught in the northeastern Chukchi and Beaufort seas were generally smaller than those caught in the northern Bering Sea (Figure 2). In the former area mean fork length was 8.8 cm (range 4.6–18.4) while in the latter area mean length was 14.7 cm (range 7.2–22.2). This difference is attributable to several factors. First, the fishes caught in the Bering Sea were generally older than those from the more northern area. In the northeastern Chukchi and Beaufort seas 1-yr-old Arctic Cod made up 81% of the catch, but in the Bering Sea they comprised only 27% of the catch. Arctic Cod older than 4 yr were caught only in the Bering Sea. Second, as indicated in Figure 2, Arctic Cod less than 4 yr old were longer at a given age in the Bering Sea than in the Chukchi and Beaufort seas. This difference was largest for 1-yr-old fishes and was progressively less in older age-classes; 4-yr-

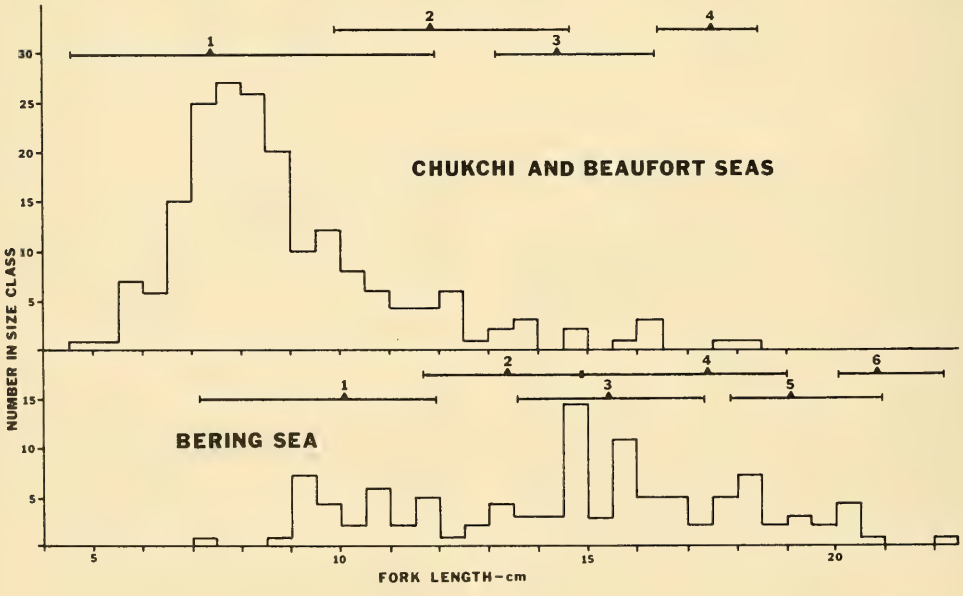

FIGURE 2. Size distribution of Arctic Cod caught in the two regions sampled. Mean (triangle) and range (horizontal bar) in size for each age-class in each region are shown above the size distributions.

old Arctic Cod were of similar length in both areas. Third, in the northeastern Chukchi and Beaufort seas small fishes (<10.5 cm) were proportionately more abundant in waters 100 m or less deep (Table 2). The size distribution of Arctic Cod from that area (Figure 2) is therefore influenced by the depth distribution of tows. Twenty-four of 33 tows were made in water 100 m or less in depth. Tows in northern Bering Sea spanned a much smaller depth range (29–80 m) and no relationship between fish size and water depth was evident.

Growth rates of Arctic Cod appear to be quite variable, especially during the first 2 yr of life (Figure 3). The transition from larvae to juvenile is reported to occur in August at a length of 3–5 cm (Rass 1968). Should we assume a mean length at transition of 4.0 cm, Arctic Cod we examined from northern Bering Sea had grown 6.1 cm in 10 mo while those from the Chukchi and Beaufort seas grew only 3.4 cm in 12 mo. First-year growth rates reported for Arctic Cod in the Barents Sea (Hognestad 1968; Gjosaeter 1973) fall between those values. Our data for the Bering Sea and that reported by Gjosaeter for the Barents Sea show the expected sequential decrease in annual length increment with age. However, in the Chukchi and Beaufort seas and in the samples from the Barents Sea examined by Hognestad, growth in length was greater in the second year of life than during the first. Hognestad found differences in postlarval growth during the first summer of life both between areas in the same year and between years at the same area. Interestingly, he found the greatest annual growth increment in the second year of life even when data for 10 sampling years was combined (Figure 3). This strongly suggests that greatest growth in length during the 2nd year of life may be common or characteristic in Arctic Cod. Reported sizes attained at the end of the 1st year of adult life vary considerably: Bering Sea, 10.1 cm; Chukchi and Beaufort seas, 7.1 cm; Barents Sea, 9.3 cm (Hognestad 1968; Gjosaeter 1973). In our samples, 4-yr-old Arctic Cod were of similar mean sizes in the Bering (17.4 cm) and the Chukchi and Beaufort seas (17.5 cm), but were smaller than that reported from the Barents Sea ($\bar{x}$ = 19.8 cm (Hognestad 1968) and 19.1 cm (Gjosaeter 1973)). Moskalenko (1964) reviewed Soviet data on growth of Arctic Cod in the Kara, Laptev, and Barents seas. He suggested two forms of Arctic Cod: a slow-growing form from coastal regions of the Kara and Laptev seas, and a fast-growing form from the Barents and Kara seas, which might be more common in the open sea. Although we cannot comment on the size and morphometric differences discussed by Moskalenko, the size at age differences observed by us and others seem adequately explained by variations in growth rates

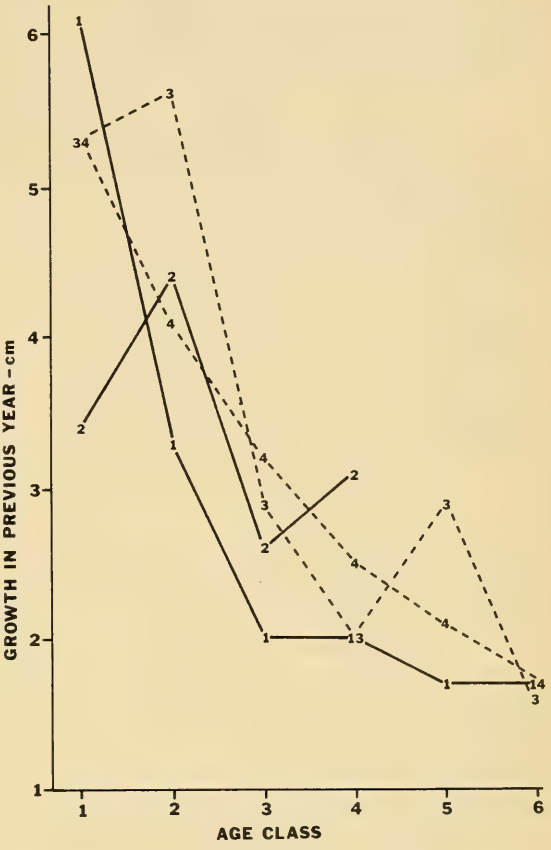

FIGURE 3. Annual growth increments reported for Arctic Cod in this study (solid lines) and other studies (broked lines).
1. Northern Bering Sea, May–June 1978.
2. Northeastern Chukchi and Beaufort seas, August–September 1977.
3. Barents Sea, August–September 1956–1966 (Hognestad 1968).
4. Barents Sea, July–September 1970–1972 (Gjosaeter 1973).

TABLE 2—Relationship between water depth and sizes of Arctic Cod caught in the northeastern Chukchi and Beaufort Seas

Depth range (m)	Fork length Mean (range)	% in length class <10.5 cm	10.5–14.0 cm	>14.0 cm
40–100	8.2 (4.6–15.9)	89.0	10.3	0.7
101–400	10.7 (6.8–18.4)	59.6	25.5	14.9

TABLE 3—Food items in stomachs of Arctic Cod collected in the northern Bering Sea, May–June 1978 and northeastern Chukchi and Beaufort seas, August–September 1977

	Northern Bering Sea, n = 73					Northeastern Chukchi and Beaufort seas, n = 157				
	Rank in stomach				Frequency of occurrence (%)	Rank in stomach				Frequency of occurrence (%)
Prey item	1	2	3	4		1	2	3	4	
Gammarid amphipod	38	11	1	—	68.4	47	40	10	—	61.8
Copepod	—	—	—	—	—	86	22	2	—	70.1
Shrimp	17	3	—	—	27.4	1	2	—	—	1.9
Hyperiid amphipod	7	—	1	—	10.9	2	7	4	3	10.2
Mysid	6	5	2	1	19.2	4	9	1	—	8.9
Euphausiid	—	—	—	—	—	2	2	1	—	3.2
Chaetognath	—	—	—	—	—	4	3	—	—	4.5
Larval capelin	4	—	—	—	5.5	—	—	—	—	—
Polychaete worm	—	2	—	—	2.7	—	—	—	—	—
Cumacean	1	—	—	—	1.4	—	—	—	—	—
Medusae	—	—	—	—	—	1	—	—	—	0.6

induced by annual variations in food availability (primary production), without invoking discrete forms in a species with a circumpolar distribution (Ponomarenko 1968).

We examined stomachs of 288 Arctic Cod. Recognizable food remains were found in 73 of 101 stomachs from the northern Bering Sea and 157 of 187 stomachs from the northeastern Chukchi and Beaufort seas (Table 3). Major prey in the northern Bering Sea, gammarid amphipods (mostly *Ampelisca macrocephala*), shrimps (mostly *Eualus fabricii* and *E. gaimardii*), and mysids (*Neomysis rayii*), were primarily benthic forms. Prey found in stomachs collected in the northeastern Chukchi and Beaufort seas indicate feeding primarily on pelagic/planktonic organisms; copepods (mostly *Calanus hyperboreus, C. glacialis, Euchaeta glacialis,* and few *Metridia longa* and *C. cristatus*) and *Apherusa glacialis*, a pelagic gammarid amphipod (Barnard 1959), were by far the predominant prey. The species of mysid eaten in this area were *Pseudoma truncata* and *Mysis litoralis* in contrast to *Neomysis rayii* in northern Bering Sea. The widely distributed hyperiid amphipod *Parathemisto libellula* was quite commonly eaten in both areas.

We examined size-related differences in foods of Arctic Cod (Table 4). In both areas, hyperiid amphipods were more commonly eaten by larger fishes, and chaetognaths were found only in smaller fishes. Overall, a greater size-related difference in foods was seen in the northern Bering Sea where the primary prey of larger cod, gammarid amphipods, and shrimps were much less commonly eaten by smaller fishes.

Similar results have been reported in other studies of foods of Arctic Cod. In the eastern Canadian Arctic, Bohn and McElroy (1976) reported copepods as the main food with pelagic amphipods and other crustaceans eaten in much smaller quantities. They found that copepods were more important in the diet of small fishes while large cod ate more shrimp. Hognestad (1968) reported that copepods were the major food of Arctic Cod collected in the eastern Barents Sea in September. Euphausiids, hyperiid amphipods, mysids, fish and shrimp eggs, phytoplankton, and small fishes have all been reported as foods of Arctic Cod in the Kara Sea (Klumov 1937; Moskalenko 1964). Similar foods have been reported from other portions of the Siberian Arctic (Moskalenko 1964).

TABLE 4—Size-related differences in foods of Arctic Cod collected in the northern Bering and the northeastern Chukchi and Beaufort seas. Only prey that occurred in more than two stomachs are included

	Frequency of occurrence (%)			
	Northern Bering Sea		Northeastern Chukchi and Beaufort seas	
Prey item	<12.0 cm	≥12.0 cm	≤10.0 cm	>10.0 cm
Gammarid amphipod	15.4	82.9	57.8	70.8
Copepod	—	—	74.2	62.5
Shrimp	15.4	46.3	2.3	4.2
Hyperiid amphipod	—	19.5	7.0	20.8
Mysid	38.5	39.0	7.0	12.5
Euphausiid	—	—	1.6	4.2
Chaetognath	30.8	—	3.9	—
Larval capelin	7.7	7.3	—	—

Our results and data available in the literature indicate considerable variability in a number of the biological characteristics of Arctic Cod. Their abundance and food habits vary both geographically and seasonally. Growth rates vary by area and by year. Abundance, feeding, and growth rates are undoubtedly interrelated in such a way that Arctic Cod optimally utilize available resources each year. Such adaptability is essential in a system with great annular fluctuations in physical (ice cover) and biological (primary productivity) characteristics and probably explains the overwhelming success of the species in Arctic waters. More data are needed before a rigorous examination of functional aspects of Arctic Cod productivity will be possible. Further studies of the biology of Arctic Cod are urgently needed to consider the ecological importance of Arctic Cod both as a potential competitor with species such as Ringed Seals (*Phoca hispida*) and Bowhead Whales (*Balaena mysticetus*) (Lowry and Burns 1980) and as a food source for many arctic marine mammals, birds, and fishes (Klumov 1937).

Acknowledgments

We thank the officers and crew members of the NOAA ship *SURVEYOR* and the USCG cutter *GLACIER* for their essential support of our collections. P. Wagner and K. Coyle aided in the identification of copepods and amphipods. Project support was provided by the United States Bureau of Land Management Outer Continental Shelf Environmental Assessment Program and Federal Aid in Wildlife Restoration Project W-17-9.

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Received 25 June 1980
Accepted 30 October 1980

Polymorphism in Colonies of the Land Snail *Cepaea nemoralis* at London, Ontario: Changes Over Three Decades

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Singh, S. M. 1981. Polymorphism in colonies of the land snail *Cepaea nemoralis* at London, Ontario: changes over three decades. Canadian Field-Naturalist 95(2): 192–197.

Genetically determined variation for band pattern in the land snail *Cepaea nemoralis* introduced into North America, provides an opportunity to study evolutionary processes. Judd reported different band patterns in two London colonies in 1952. In 1979, I located seven additional well-established colonies in London. The degree of polymorphism in 1979 colonies (75–87%) was comparable to values obtained for the 1952 colonies. Colony A of 1952 formed a separate lineage in the "similarity" dendrogram whereas colony B grouped with three 1979 colonies. Four other 1979 colonies formed their own grouping, suggesting differentiation during the process of colonization.

Key Words: *Cepaea*, land snail; polymorphism, evolution, genetics.

The land snail *Cepaea nemoralis* is a western European species. It is common to a wide variety of habitats at different altitudes ranging from dunes to cultivated fields. Since the time of Linnaeus it has been known to be one of the most polymorphic members of the European fauna. From the examination of fossil specimens, Diver (1929) showed that this species has been polymorphic for its banding patterns since the Neolithic period and commented that it has remained approximately constant since then. Various aspects of the ecology of *Cepaea* have been extensively studied and information is available on its biologically important ecological characteristics (Jones et al. 1977). The genetics of its visible polymorphism (band patterns) is fairly well understood (Cain et al. 1960; Cain and Sheppard 1957; Cook 1967; Lamotte 1951; Wolda 1969; Murray 1975). The band pattern polymorphism is extensive in most colonies and is easy to score. About 10 000 populations have been studied in their natural habitat. In every colony a number of different morphs are observed and various colonies are distinguished by ratios of these phenotypes (Murray and Clarke 1978).There is a wide range of opinion among biologists as to the evolutionary mechanisms at work in causing and maintaining this polymorphism in natural populations. Among others, Cain and Sheppard (1950, 1954) and Clarke (1960, 1962) attributed the differences in the frequency of various morphs between colonies to selection by predators against most conspicuous morph(s); others, however, attributed this difference to random drift and founder effect (Lamotte 1959; Goodhart 1963), "cryptic" environmental factors (Cain and Currey 1963), and climatic selection (Arnold 1968, 1971; Jones 1973). The relative importance of these forces stays an unresolved problem (Jones et al. 1977).

A long-term follow-up of the changes in the frequency of different morphs along with the dispersal and development of new colonies under different ecological circumstances is essential in evaluating and understanding evolutionary forces. Unfortunately, well-documented studies of morph (gene) frequencies over long periods of time are not common. The color polymorphism in the Peppered Moth, *Biston betularia* (Kettlewell 1965; Ford 1971), probably provides the best example of this kind. Murray and Clarke (1978) reported gene frequency changes over a 50-year period in *Cepaea* inhabiting the coastal sand dunes at Berrow, Somerset, England, an area which has stayed fairly stable. In this paper, I report on the changes in morph frequencies and the development of new colonies of *C. nemoralis* in London, Ontario, located within the city limit in gardens, parks, backyards, and river banks. The area has undergone extensive urban development and thus has subjected the existing fauna to differential selection pressures.

Banding Patterns of the London Colonies in 1952

Cepaea nemoralis was introduced to North America around 1857 (Reed 1964). Pilsbry (1928, 1939) reported colonies of introduced *Cepaea* at various locations in the USA and Canada while the occurrence of *C. nemoralis* in the London, Ontario, area was reported at different times by Pilsbry (1928), Latchford (1930), and Oughton (1948). The species is now fairly abundant in southern Ontario. Judd (1953, 1955) was the first to report on the band pattern frequencies in the two colonies he observed in 1952 in London.

The five bands on the shell (Figure 1) are numbered from the top down: 1, 2, 3, 4, 5, and a pattern of five

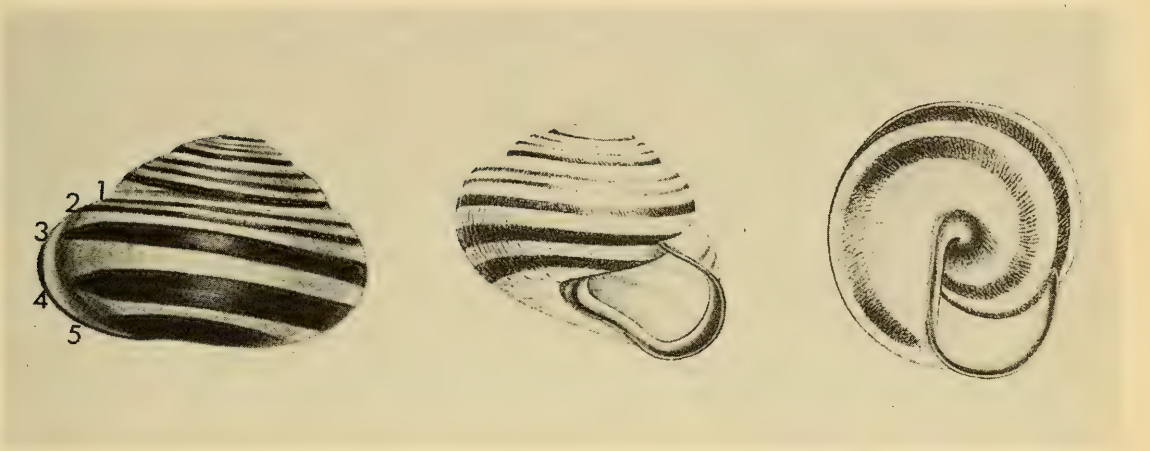

FIGURE 1. Three views of a five-banded *Cepaea nemoralis* shell. Bands are numbered.

separate bands is designated as 1 2 3 4 5. A missing band is designated by '0.' A complete fusion of two bands is designated by a round bracket and an incomplete fusion by square brackets around the bands involved. Presence or absence of any combination of five bands along with fusion of any two or more bands provides a large number of possible phenotypes in any colony. In the first colony (A) which was located near the western city limits on grassy plots, Judd (1953) found that over 90% of the shells expressed all five bands. Of these 35% were 1 2 3 4 5, 43% were 1 2 3 [4 5], and 10% were 1 2 3 (4 5). All other 27 recognized patterns were present in much lower frequencies. In a sample size of 1000, 13 of these patterns were represented by single individuals and 5 by only two individuals. For others the frequencies were less than 2% each. Thus characteristically this population was predominantly 1 2 3 4 5 type with some fusion of bands 4 and 5. Furthermore, there were no 0 0 3 - - (0 0 3 with presence or absence of bands 4 and/or 5) individuals in this colony. In a second colony (B) which was located in a well-maintained garden within the city limit 5 km NE of the first colony, Judd (1955) noted that the frequencies of banding patterns were significantly different from the first colony. About 25% of the snails were 0 0 - - -(absence of bands 1 and 2) as compared to 1/1000 in the first colony. The fusion of bands 1 and 2 was pronounced in the second colony (41%) as compared to the first colony (2%). Furthermore, the band pattern 0 0 3 0 0 was present only in the second colony. This study was undertaken to see if more colonies of *C. nemoralis* have developed since 1952 and how they compare with the findings of Judd (1953, 1955) in this area.

Materials and Methods

During the summer of 1979, 10 additional colonies of *C. nemoralis* were located within the city boundaries of London, Ontario. At least 200 mature individuals were available for scoring from seven of these colonies. The description of the habitat of these colonies is as follows:

Colony 1. Located in the middle of residential area at the low-lying edge of a heavily used playing field in a park. The ground is covered with various grasses and goldenrod (*Solidago* sp.) and shaded by large trees. It leads to a drainage area having a marshy appearance and faces a high bank behind housing. Total area approximately 15 × 15 m.

Colony 2. Located about 200 m SE of Colony 1 in the same park area separated by a road. It is more elevated with very little ground vegetation and densely shaded by a large number of small trees. Total area approximately 15 × 15 m.

Colony 3. Located in a backyard of an old residential area about 10 city blocks to the north of Colony 1. It has a history of gardening with grasses and small hedges. Approximate area 5 × 5 m.

Colony 4. Located on the river bank about 3.5 km N of Colony 1. The area is covered with dense vegetation including goldenrod, wild grape (*Vitis* sp.), and small bushes. Approximate area 10 × 30 m.

Colony 5. Located in a small patch (5 × 5 m) of goldenrod bordering dense coniferous trees in a heavily used campground about 12 km NE of Colony 1.

Colony 6. Located on the bank of the river in a small shady area (5 × 5 m) under two low trees with predominantly grass covering approximately 3 km S of Colony 1.

Colony 7. Located in a low-lying grassy area on the bank of a drainage channel under high trees about 200 m from Colony 6. Approximate area 5 × 7 m.

Collected individuals were scored for their band pattern following the usual method. Animals were returned to their colonies after scoring. An attempt will be made to follow these and other London colonies at yearly intervals to obtain long-term data. This will be a further attempt to understand processes of colonization, selection, and population differentiation in *Cepaea* in a changing habitat.

Data I obtained were used to compare band patterns of 1979 and 1952 colonies, to establish a degree of similarity statistically between seven 1979 and two 1952 colonies, and to assess a degree of polymorphism, an index of variability, in these colonies.

Results and Discussion

Table 1 records the banding pattern of 1598 live adult snails collected from seven colonies in 1979, plus 2000 from two colonies in 1952. Yellow morphs predominated in all these colonies. It is evident that the two colonies of 1952 are very different for the frequency of band patterns ($P \leqslant 0.95$). Bands 1 and 2 are absent in 25% of the individuals in colony B while only one individual in a sample size of 1000 shows this pattern in colony A. Also the fusion of bands 12 and/or 45 is more pronounced in colony B. The 1979 colonies are similar to 1952 colonies in many respects. Most of the major morphs were present in both groups. The differences observed in 1952 between the A and B colonies were also present between colonies in 1979. Similar to colony A, colonies 2 and 5 have zero frequency for 0 0 3 0 0 morph and its frequency is comparable to the B colony in colonies 1, 3, and 4. Colonies 6 and 7 have very high frequency of this morph (76/302 and 74/272, respectively). Other morphs (where bands 1 and 2 are absent), namely, 0 0 3 4 5, 0 0 3 [4 5], and 0 0 3 (4 5) are present in all

TABLE 1. Comparison of the banding pattern in London colonies of *Cepaea* studied in 1952 (A, 27 April; B, 5 September) and 1979 (August and September)

	Colonies in 1979							Colonies* in 1952	
Pattern	1	2	3	4	5	6	7	A	B
12345	4	28	52	60	68	122	110	353	104
123[45]	8	6	8	4	8	22	8	429	20
123(45)	16	28	24	24	35	36	16	102	183
(12)345	1	0	2	1	2	1	2	0	4
[12]3(45)	24	8	6	7	12	12	19	19	31
(12)3(45)	66	47	45	18	20	14	0	266	
[12]345	1	0	0	1	1	2	0	0	4
[12]3[45]	0	0	1	2	0	0	1	0	10
[123](45)	22	11	3	7	8	0	0	0	24
(123)(45)	0	4	0	4	3	0	0	0	59
[12345]	0	2	0	0	0	0	0	15	2
12345	0	0	0	0	0	0	0	13	0
123[45]	0	0	0	0	0	0	0	19	0
12045	1	3	1	0	1	0	4	7	0
(12)0(45)	4	22	1	8	4	0	1	0	4
120[45]	0	1	1	0	1	0	2	4	0
0234	0	0	0	0	0	0	0	8	0
023(45)	0	0	0	0	0	0	0	5	0
003[45]	1	4	12	0	3	0	0	1	10
003(45)	62	18	16	3	21	0	4	0	139
00345	14	2	52	13	8	8	14	0	50
00300	2	0	12	3	0	76	74	0	49
Others	4	11	3	9	5	3	3	25	41
Total	230	195	210	191	198	302	272	1000	1000
Polymorphism index	0.815	0.872	0.867	0.871	0.835	0.765	0.757	0.680	0.856

*Modified from Judd (1955).

colonies of 1979 but were found only in the B colony in 1952. The degree of fusion between two or more bands when all five bands are present, however, varies from colony to colony in 1979 as in 1952. The frequency of fused bands 3 and 4, when bands 1 and 2 are absent, was quite variable and ranged from 0% in colony 6 to 27% in colony 1. Others, like colonies 2, 3, and 5, had intermediate frequencies around 10%. A number of rare morphs that are lumped together as "others" varied from colony to colony and were represented by very few individuals in each sample.

Judd (1955) postulated that the bandless pattern "would probably soon become prevalent when once established" owing to its dominant nature over the banded forms (Stelfox 1918); but the frequency of a given form is not dependent on whether it is dominant or recessive. Genetic dominance is totally unconnected with gene frequency, as shown by the Hardy–Weinberg equilibrium law. The frequency of a given morph or rate of its increase is dependent on its relative Darwinian fitness in a Mendelian population (see Spiess 1977 for details).

The similarity among seven 1979 plus two 1952 colonies for their banding pattern was evaluated by obtaining minimum spanning distance based on two main principal components (Figure 2). Although the two principal components account for only 58% of the variance, the relative position of different colonies in this network is comparable to the dendrogram (Figure 3) based on similarity indexes between pairs of colonies which utilized all the information. The CLUSTAN 1C computer program (Wishart 1975) was used for obtaining the patterns in both figures. Colony 4 of 1979 and B of 1952 are most similar for their band patterns. Furthermore all 1979 colonies are closer to the B colony as compared to the A colony of 1952, although the patterns that were specific to the A colony in 1952 are observed in different proportions in all colonies of 1979. This suggests differential mixing of existing colonies in the development of new colonies and/or some form of selection imposed by factors associated with urbanization of the study area.

Samples from the colonies of 1952 and 1979 were also compared using a diversity (polymorphism) index (Simpson 1979). Here the probability of finding individuals of different morphs when two are sampled at random from an infinite population $= (1 - \sum_{i=1}^{m} p_i^2)$, where p_i is the frequency of the ith morph and m is the number of morphs. An unbiased estimate of $\sum_{i=1}^{m} = p_i^2$ is given by $\sum_{i=1}^{m} n_i \frac{(n_i - 1)}{N(N-1)}$ where n_i is the number of the

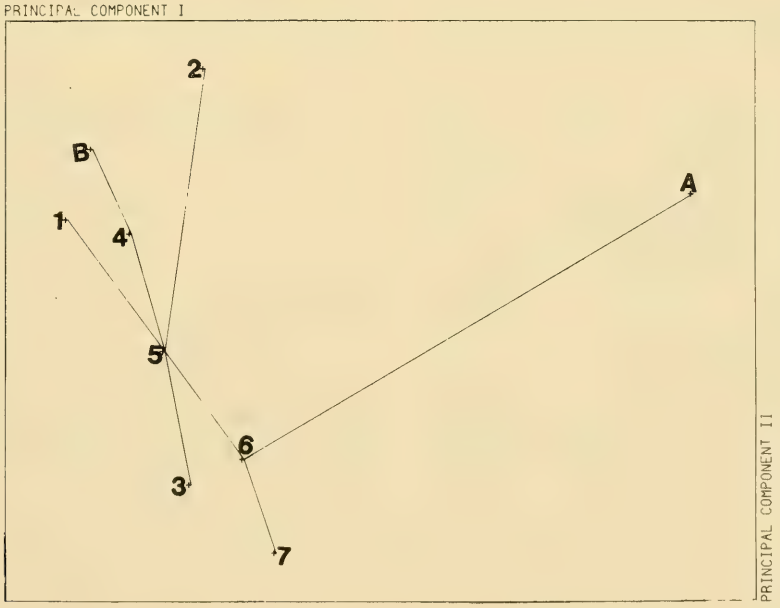

FIGURE 2. Minimum spanning tree based on two principal components of band pattern variation showing relationship between London colonies studied in 1979 (1–7) and 1952 (A and B).

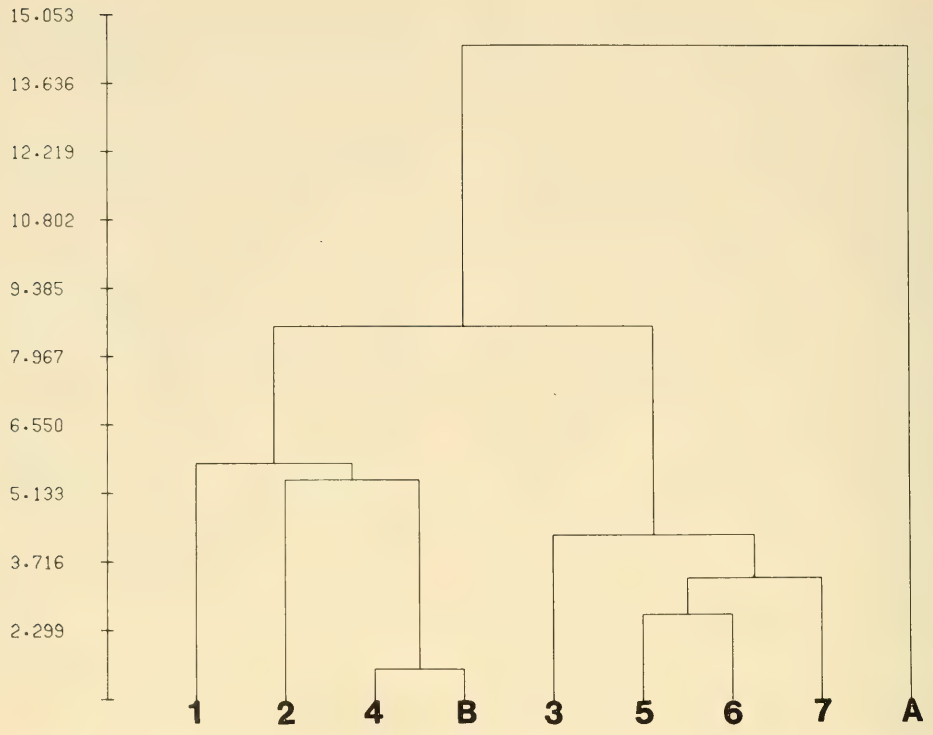

FIGURE 3. Dendrogram showing relationship between 1979 (1–7) and 1952 (A and B) colonies of London based on similarity in their banding patterns. (*Y* axis numbers — Ward's coefficient of dissimilarity).

*i*th morph and *N* is the sample size. For a monomorphic sample the value for this index is zero and the maximum value will be $(m - 1)/m$ for a population with equally frequent *m* morphs. It is obvious that all populations are fairly polymorphic (bottom row, Table 1), although there are differences between the frequency of various morphs in these colonies. In the city of London the ecological characteristics obviously have changed since 1952 with increase in population density, and new colonies of land snails have been founded during this period. However, the diversity (polymorphism) index is comparable between the colonies observed in 1952 and 1979. This may reflect on the inherent property of the species and may be explained by the reproductive biology and colonizing property of *Cepaea*. It is monoecious, an obligate outcrosser, has multiple matings, and stores sperm from many of them (Murray 1964). One mature individual may well represent several individual genomes in terms of its reproductive potential. The genetic effect of each colonizing individual, therefore, is greater than in most other species.

The extensive body of information on *Cepaea* polymorphism has led to an increase in the complexity of our explanations of genetic variation, rather than to the emergence of a single unifying explanation. Jones et al. (1977) suggested that this polymorphism cannot be explained by simplistic models which depend entirely on random processes, entirely on one type of selection, or even on a few types of selection. At least eight evolutionary forces are known to affect shell polymorphism in *Cepaea* and, in most populations, several of these in fact may act simultaneously to control morph frequency (see Jones et al. 1977 for review). Unique combination of these evolutionary explanations is needed for almost every *Cepaea* population. Furthermore it is not possible to produce general rules from limited studies on few populations.

The pattern of variation in North American colonies may reflect circumstances involved in their introduction and founder effect rather than deterministic processes like millenia of selection in local environments. Selection may be the reason for the extinction of some known colonies that were not found even after diligent searches. Additional studies over long periods are necessary to assess the effects of stochastic

processes and natural selection in North American populations of *C. nemoralis*, an excellent species for ecological/evolutionary genetic studies.

Acknowledgments

I express my thanks to W. W. Judd and D. M. Scott for helpful advice on colonies of *Cepaea* in London and to Roger Green for statistical advice. Financial support was provided by a Natural Sciences and Engineering Research Council research grant.

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Received 28 April 1980
Accepted 10 November 1980

Scheduling Censuses of Breeding White Pelicans (*Pelecanus erythrorhynchos*) in Northern Alberta

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Beaver, Rick D., and Victor Lewin. 1981. Scheduling censuses of breeding White Pelicans (*Pelecanus erythrorhynchos*) in northern Alberta. Canadian Field-Naturalist 95(2): 198–201.

In May 1976 and June 1977 aerial surveys were flown over Birch Lake in northeastern Alberta to determine the numbers of White Pelicans (*Pelecanus erythrorhynchos*) occupying nests. Ground counts conducted concurrently with the 1977 aerial surveys revealed that the aerial counts included some pelicans not occupying nests. Pelicans that were present but not occupying nests were loafing birds, either non-breeders, mates off the nest, or both. Evening rather than morning census flights are preferable, because the number of such loafing pelicans appeared then to be lower. Censuses to record numbers of incubating pelicans in northern Alberta should be conducted in late May or early June during the peak of the incubation period.

Key Words: White Pelican, *Pelecanus erythrorhynchos*; aerial census, breeding colonies, Alberta.

During 1976 and 1977 we studied breeding White Pelicans (*Pelecanus erythrorhynchos*) at Birch Lake (local name; 57°14′N, 112°44′W) in northeastern Alberta. Several biases that we found in the census techniques used to estimate the breeding population are reported here. These may be applicable in other areas in Canada as well (Trottier et al. 1980).

White Pelicans nest on remote islands in permanent or intermittent water bodies, and they frequently occupy sites which are not heavily forested (Behle 1958; Vermeer 1970; Strait 1973; Beaver and Ballantyne, unpublished data[2]). Such colonies, which may be composed of several discrete subcolonies, usually offer unobstructed viewing from the ground or from the air. Determination of the number of nests by visits on the ground can cause abandonment of the site by the pelicans (Farley 1919; Carson 1966; Sanderson 1966; Vermeer 1969; Johnson and Sloan 1976), and the practice should be discouraged. Gull predation, and heating, chilling, or trampling of nest contents also may result from activities that force adults to abandon their nests (Johnson and Sloan 1976). Nest censuses should therefore entail minimal disturbance, particularly if subsequent productivity (fledgling) surveys are to be reliably free from the bias introduced by research activities.

Study Area

The Birch Lake colony, a small island consisting of sand, clay, and scattered rock, is essentially free of vegetation and hence offers an unobstructed view of the pelicans. The island, about 2 m above lowest water levels (observed in 1977), is subject to periodic flooding caused by Beaver (*Castor canadensis*) dams on the outflow drainage of Birch Lake. Birch Lake covers an area of about 1.7 km^2. The island was almost completely covered by rising water levels in the summer of 1976, but in 1977, because of periodic removal of the beaver dams, water levels were lower and the island measured 90 × 23 m.

In 1976 and 1977, 15 and 25 pairs of California Gulls (*Larus californicus*), respectively, were nesting associates of the pelicans. The gulls, although they had arrived earlier in the spring, were subsequently displaced to nesting locations peripheral to the pelican subcolonies.

Methods

Data from literature on other colonies in Canada were used to select the 27 May census date in 1976. The 8 June 1977 survey date was selected after prior observations that year revealed a peak in the number of pelicans incubating at that time. A Cessna 185 aircraft was flown directly over the colony at elevations of 600, 450, and 300 m at 09:00 on both dates. Photographs of the colony were taken at each elevation using 55- or 200-m lenses on a hand-held 35-mm single-lens reflex camera with Kodak ektachrome 160, kodachrome 64, and Plus-X Pan film. Black-and-white enlargements and projected color slides were used when counting the pelicans photographed on the island from the air.

In 1977 we made 16 counts of the numbers of loafing birds (birds not occupying nests) as well as incubating birds from 8 to 13 June. An observation platform, constructed for the purpose, was situated 1 m above water, about 300 m from the island. We conducted the counts with the aid of a 15-60 power spotting scope over the course of several days at different

[2]Canadian Wildlife Service AOSERP (Alberta Oil Sands Environmental Research Program) 1979. Report 82. 93 pp.

times of the day. The presence of pelicans loafing on the island obscured our view of some incubating birds. Birds thus imperfectly seen were assigned to the two categories (loafing or incubating) by assuming that the same proportions of nesting or loafing birds existed among those not clearly visible as among those that were clearly either on or off nests. Although loafing birds regularly congregated at certain areas of the island, they did not do so exclusively. Birds observed at these areas, which were always located apart from established subcolonies, were considered to be loafing.

Results and Discussion

The chronology of events seems to be similar at all colonies in Canada (Table 1) although there is some variability (Vermeer 1970).

The Birch Lake pelicans established nests over a 4-wk period in 1976 and a 2-wk period in 1977. Seven individual subcolonies (two in 1976, five in 1977) were established in a mean of 9.3 d (range: 7–14 d) (Table 2). The length of the period when most incubating birds would be counted may be expected to vary. Factors such as infertile eggs, weather, disturbance, or fluctuating water levels can cause abandonment of nests, and less reliable census data would result from later censuses because the evidence (Schaller 1974) indicates that White Pelicans do not renest. If surveys had been made after 1 June in 1976, a number of incubating birds would not have been counted. Subcolonies were established over a 4-wk period and some birds in the first subcolony formed were nearing the completion of incubation by 1 June in 1976. In 1977, ground observations before 8 June were indispensable in determining the best time for censusing. All birds were incubating by 4 June with earliest nesting birds about 19 d into incubation. An aerial census for incubating birds was then scheduled for 8 June to ensure a maximum count.

Schaller (1964) and Knopf (1975) stated that nest reliefs for incubating White Pelicans occurred around midday. Aerial censuses conducted at times other than midday should have avoided counting birds that were not on nests (i.e. loafing birds) as only one member of the pair is present except during nest reliefs (Schaller 1974; Knopf 1975). Boeker (1972) employed a morning aerial census to determine the number of occupied nests during the peak incubation period and multiplied this figure by 2. We also used this technique; however, ground observations at Birch Lake revealed a potential bias due to the presence of loafing birds on the island throughout the day. These birds would have been indistinguishable from incubating birds in the photographs.

Projections of color transparencies (Kodak ektachrome 160), taken at 300 m above ground level with the 200-mm lens, provided the best image. Larger format cameras might have further improved resolution. Using the projections, we tallied 140 pelicans in 1976 and 70 in 1977.

Sixteen ground counts from 8 to 13 June in 1977 (Table 3) revealed a mean of 70.1 (range 59–75; SD 3.9) birds on nests. The 1977 aerial count was thus accurate, but this was fortuitous, as ground checks revealed.

The proportion of pelicans not clearly visible in ground counts varied from 0 to 21% of the total numbers present on the island. Adjustment as out-

TABLE 1—Timing of annual cycles at several Canadian White Pelican colonies

Colony	Year	Spring arrival	Incubation	Cessation of brooding	Autumn departure	Source
Stum Lake, British Columbia	1964		Mid-May–early June			Campbell and Frost 1969
Birch Lake, Alberta	1976	Late April	May–June	June–July	September	This report
	1977	Late April–late May	May–June	July	September–October	This report
Beaverhill Lake, Alberta	1975	3–31 May	Did not breed		Early September	Weseloh et al. 1975
Lavallee Lake, Saskatchewan	1975	Late April–May	May–June	June–July	August–September	Trottier et al., 1980
Dog Lake, Manitoba	1965		May–June			Anderson and Bartonek 1967
Pelican Lake, Manitoba	1964	Late April–May	May–June	June–July		Anderson and Bartonek 1967
East Shoal Lake, Manitoba	1964, 1967, 1971		May	June–July		Hosford 1965
			May	June–July		Evans 1972
Lake of the Woods, Ontario				June–July		Lies and Behle 1966

TABLE 2—Subcolony size and chronology of White Pelicans nesting at Birch Lake in 1976 and 1977. NA, not applicable; ND, no data

	Number of nests[b]		Courtship		Incubation		Brooding	
Subcolony[a]	1976	1977	1976[c]	1977	1976[c]	1977	1976[c]	1977
A	70	28	27 April–4 May	11–24 May	4 May–3 June	22 May–21 June	4–25 June	22 June–13 July
B	53	10	ND	18–26 May	ND	26 May–25 June	ND	26 June–27 July
C	13	13	ND	25 May–4 June	ND	4 June–4 July	ND	5–26 July
D	4	11	25 May–1 June	26 May–1 June	1 June–1 July	1 June–1 July	25 June–15 July	2–23 July
E	NA	8	NA	28 May–4 June	NA	4 June–4 July	NA	5–26 July

[a]Subcolony designations were assigned to spatially and/or temporally separated groups of breeding birds and do not necessarily imply the integrity of subcolony units from year to year.
[b]Determined from aerial censuses of incubating birds.
[c]Dates in 1976 are based on estimates derived from backdating from developmental characteristics of young (Schaller 1964) already hatched when study began and Knopf's (1975) observation that incubation lasts about 30 d. These estimates were validated by actual observation of events at Birch Lake in 1977.

TABLE 3—Numbers of loafing and incubating White pelicans at the Birch Lake colony during counts conducted at different hours of the day from 8 to 13 June 1977

Time period	Number of days checked	N[a]	Number of incubators, mean (range)	Number of loafers, mean (range)
06:00–10:00	2	5	71.4 (68–75)	14.2 (2–25)
10:00–16:00	3	5	68.8 (59–73)	9.5 (0–40)
16:00–22:00	2	6	70.0 (65–73)	6.0 (1–13)

[a]N = number of counts made during time period.

lined in the Methods gave a mean of 11% loafing birds (range 0–40%; SD 12%) from 8 to 13 June in 1977. The proportion of loafing birds appeared to decline throughout the day and was least variable in late afternoon/evening based on 16 counts (Table 3).

Estimates of numbers of nesting White Pelicans derived from aerial photographs taken during the peak incubation period thus appeared to be potentially variable owing to the presence of up to 40% loafing pelicans. A ground count is thus deemed more accurate than an aerial census of nesting pelicans. The former, if conducted by distant observation where the nesting areas are clearly visible, would eliminate disruptive intrusions in the colonies.

In summary, from this study we conclude that aerial censuses to count incubating pelicans should be conducted during late May or early June, the peak incubation period in Canada. Further we suggest that evening census flights might be more accurate than morning flights, as the proportions of loafing birds appear to be lower in the evening. Concurrent ground counts and census flights at other locations, however, are desirable to validate the potential biases suggested here.

Acknowledgments

We gratefully acknowledge financial assistance by the Alberta Oil Sands Environmental Research Program for this study. We thank D. Ealey, K. Zurfluh, A. Richards, D. Richards, and M. Ballantyne for assistance with the field work. C. Boyle and D. Hadler (field operations staff, Alberta Oil Sands Environmental Research Program) provided valuable logistic assistance. Our appreciation is conveyed to E. Kuyt, L. Allan, and G. Trottier of the Canadian Wildlife Service for their helpful criticism of earlier drafts of this manuscript.

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Received 10 March 1980
Accepted 11 November 1980

Notes

Nesting Northern Gannets (*Morus bassanus*) Killed by Rock Falls at Great Bird Rock, Quebec

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Kirkham, Ian R. 1981. Nesting Northern Gannets (*Morus bassanus*) killed by rock falls at Great Bird Rock, Quebec. Canadian Field-Naturalist 95(2): 202–203.

Nine Northern Gannet (*Morus bassanus*) adults and six eggs were crushed by a falling rock at Great Bird Rock. Falling rocks and related seabird mortality are probably common at this colony as the islands are slowly eroding away.

Key Words: rock falls, Northern Gannets (*Morus bassanus*), Great Bird Rock, erosion, accidental mortality.

During my study of Northern Gannets (*Morus bassanus*) on Great Bird Rock (47°50′N, 61°09′W), Magdalen Islands, Quebec, in May 1979, I saw two dead adult gannets floating in the water at the base of the eastern cliffs. As I climbed down the cliff to collect the dead birds, I saw that a large rock (0.3 × 1.5 × 2.5 m) had broken away, falling about 3 m and coming to rest on a group of incubating gannets. Four dead adults were visible on their nests. Given the local nesting density, it is likely that at least two more nests were destroyed beneath the rock. An estimated nine adults were killed and six eggs destroyed, including the two birds on the water and a dead adult on the shore below the rock fall. Lightkeepers gave me accounts of other rock falls which killed gannets. In 1973, 24 dead gannets were in the water near the northeast point of the island where part of the cliff had collapsed on a group of nests (D. McLean, Entry Island, Magdalen Islands, P.Q. G0B 1C0, personal communication). In May 1978, W. Dixon (Entry Island, Magdalen Islands, P.Q. G0B 1C0, personal communication) saw a large number (> 30) of dead gannets along the northern shore of the island and in the water beneath a nesting area where a large overhanging section of the top shelf had given way. Along the northern end of the island, rock slides are frequent (D. McLean, personal communication) and during my 26-d stay a slide there destroyed about 20 nests.

The Bird Rocks were possibly once the largest gannetry in the world, estimated at about 112 000 pairs in 1833 (Gurney 1913). Recently this colony was estimated at 5331 pairs (Nettleship 1976). The two obvious reasons for the population decline are (1) the erection of a lighthouse in 1869, which discouraged possibly 50 000 pairs from nesting during the next 20 years (Lucas 1888), and (2) the reduction of breeding sites through erosion of the islands. In a short period of time, Little Bird Rock has apparently eroded greatly. A third island, located on the shoal between the two Bird Rocks, was seen by Cartier in 1534 but disappeared before the 19th century (Lucas 1888). The Bird Rocks are remnants of a once extensive rock formation and consist primarily of red sandstone which is fine-grained and poorly consolidated. They have a weathered appearance due to the small amounts of calcite which have mostly eroded away and left a porosity of close to 45% (Sanschagrin 1964).

Most of the mortality due to rock slides at breeding sites would be expected to occur during spring thaw which causes multiple fractures and disintegration of rock. Reports of deaths related to rock falls among gannets appear to be confined to the Bird Rocks, except for a small colony on Grimsey, Iceland, that disappeared owing to falling cliff material above nesting sites (Gudmundsson 1953). The long-term effect of the erosion and rock slides at Bird Rocks will be a decline in the number of breeding birds, owing to a reduction in the number of safe nesting sites, and eventually one of the oldest and once the largest gannetry in the world will disappear.

I thank the lightkeepers of Great Bird Rock for providing information about the gannets, Christopher Lynas for reviewing the geological reports, and William Montevecchi for reviewing the manuscript. Support was provided by a Canadian Wildlife Service student scholarship and a NSERC grant A0687 to W. A. Montevecchi.

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Received 21 May 1980
Accepted 27 August 1980

Postglacial Fossil Fishes from Coppermine River, Northwest Territories, Canada

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McAllister, Don E. and Denis St-Onge. 1981. Postglacial fossil fishes from Coppermine River, Northwest Territories, Canada. Canadian Field-Naturalist 95(2): 203–205.

Fossils remains referred to Arctic Charr (*Salvelinus alpinus*), Arctic Grayling (*Thymallus* cf. *arcticus*), Northern Pike (*Esox* cf. *lucius*), and Slimy Sculpin (*Cottus cognatus*), were collected from freshwater, sandy-silt deposits at 66° 50′N, 115° 55′W. These may provide the earliest yet known Northwest Territories records of fishes originating from the Mississippian or Beringian refugia approximately between 8400 and 9000 years BP.

Key Words: fossil fishes, Coppermine River, Northwest Territories, *Salvelinus alpinus, Thymallus arcticus, Esox lucius, Cottus cognatus,* Pleistocene.

McAllister, Don E. and Denis St-Onge. 1981. Postglacial fossil fishes from Coppermine River, Northwest Territories, Canada. Canadian Field-Naturalist 95(2): 000–000.

Des débris fossils d'Omble Arctique (*Salvelinus alpinus*), d'Ombre Arctique (*Thymallus* cf. *arcticus*), de Grand Brochet (*Esox* cf. *lucius*) et de Chabot Visqueux (*Cottus cognatus*) furent trouvés dans un dépôt de limon sableux à 66° 50′N, 115° 55′W. Ces restes représentent peut-être les témoins les plus anciens de poissons en provenance des refuges Mississipien ou Beringien des Territoires du Nord-Ouest approximativement entre 8400 et 9000 ans AP.

Mots clefs: Poissons fossils, Rivière Coppermine, Les Territoires du Nord-Ouest, *Salvelinus alpinus, Thymallus arcticus, Esox lucius, Cottus cognatus,* Pliéistocène.

In this note we report on post-Wisconsin fish remains found in the valley of the Coppermine River at 66° 50′N, 115° 55′W, north-central District of Mackenzie, Northwest Territories. The Quaternary fish fauna of Canada is poorly known and Harington (1978) reports only two fossil fish collections for the Northwest Territories, and fishes from one of these have not been identified.

The fish remains occurred in an organic silty-sand unit, 1 m thick, at the top of a section which forms a 61-m-high bluff on the north side of the Coppermine River. Most of the outcrop is composed of outwash (sand, gravel, and drop stones) resting on an irregular till surface (boulders in sand–gravel matrix). These sediments are part of a hummocky terrain within the valley that are capped, in part at least, by the fossiliferous silty sand. A perched delta, 300 m upstream, marks the level of a major glacial lake which formerly occupied the valley (Glacial lake Coppermine, St-Onge, in press). The 1-m-thick organic silty sand in which the bones were found appears to be river flood deposits which occur at an altitude similar to that of the delta.

Another major section, 30 m high, is exposed along a small stream (Quicksand Creek, 66° 49′20″N, 116° 21′W), 15 km downstream from the high bluff. It shows three major units: bouldery till at the base; 22–25 m of varved sandy silts and clays covering the bouldery till; cross-bedded deltaic sands, 5–8 m thick which overlie the varves. In the deltaic sands is found a former channel filled with silty sand, rich in organic debris, and capped by a dense peat bed. The channel sequence is about 4 m thick. A piece of willow (*Salix* sp.) at the base of the channel fill has yielded an age of

8400 ± 80 (GSC-2959) while the peat at the top of the fill gave an age of 3210 ± 60 (GSC-2998).

National Topographic Series maps recently published (1979) by the Canadian Department of Energy, Mines, and Resources at a scale of 1:50 000 show that the top of both sections is at approximately 320 m asl. What then is the relationship between the fossil fish bed and the dated units in the Quicksand Creek section? It is difficult to imagine water being present at the top of the hummocky terrain unless it was part of Glacial Lake Coppermine. Because the fossiliferous bed occurs at an elevation corresponding to the highest level of the lake, it is reasonable to assume that the fish were alive during that period of maximum lake elevation, probably 8400–9000 years BP. This deduction has considerable paleoecological implications and will require substantiation by radiocarbon dating of organic material from the fossiliferous beds.

The fish remains studied consisted of numerous bones and scales, little eroded, in fine silty sand. All the bones and scales apparently originated from small specimens about 120 mm in standard length.

Species of Fossil Fishes

Four taxa of fishes were determined. From the bones identified, the relative frequency of taxa, with the most frequent first, seemed to be *Thymallus, Esox, Salvelinus,* and *Cottus*; the taxonomic position of many other bones difficult to determine were not identified. Catalogue numbers are those of the Paleobiology collection, National Museum of Natural Sciences, Ottawa.

Salvelinus alpinus, Arctic Charr

A single dentary (NMC 36122), 8.0 mm long, with the tips of the larger teeth hooked and pointing posteriorly, was identified as Arctic Charr. Jaw and tooth form distinguish this fossil from the Lake Charr (= Lake Trout, *Salvelinus namaycush*).

Harington (1978) did not list *Salvelinus alpinus* amongst the known Quaternary fishes of Canada and Alaska, so this specimen provides the first fossil record for this species in North America.

Thymallus c.f. *arcticus,* Arctic Grayling

Several small scales (NMC 36123) about 1.8 mm in diameter from juveniles of this species with their characteristic crenulate border (about five crenulations) were found. Among Canadian arctic fishes the Northern Pike (*Esox lucius*) is the only other species with crenulate scales, but the scales of pike have grooves running posteriorly from the crenulations, a feature lacking in these specimens.

We refer them to *T. arcticus*, rather than one of the Palearctic species, solely on the basis of provenance. Pleistocene *T. arcticus* have been reported from the Yukon Territory by McAllister and Harington (1968).

Esox c.f. *lucius,* Northern Pike

This species is represented by a few small dentaries (NMC 36124) about 11 mm long with teeth characteristic of the genus.

The fossils are identified as *E. lucius* instead of *E. niger, E. americanus,* or *E. masquinongy,* because it is unlikely that these three species would be found in the cool northern waters so soon after deglaciation. Evidently the Coppermine was deglaciated about 9500 BP. *Esox lucius* has been reported from late Pleistocene deposits in the Yukon Territory (Crossman and Harington 1970).

Cottus cognatus, Slimy Sculpin

The species was represented by a single almost complete preoperculum (NMC 36125). It is identified as *Cottus cognatus* rather than *Cottus ricei* because the spine forms a V with the body of the bone instead of a U. The bone is about 6.4 mm long, the spine 1.2 mm long. S. L. Cumbaa, D. E. McAllister, and R. E. Morlan have discovered a vertebral centrum attributable to *Cottus* from Pleistocene deposits in the northern Yukon Territory.

Discussion

The fossils bear significantly on the timing of dispersal of these species. All four had refugia in both the Beringia and the Mississippi system. Pike probably entered the upper Mackenzie from the Mississippi (McPhail and Lindsey 1970), hence the Coppermine population probably reached the area from the same source. These fossil pike thus fix the earliest known date for fish of Mississippian origin to have arrived in arctic Canada.

Slimy Sculpins presently in the Coppermine area appear to be intergrades between populations which survived glaciation in Beringian and Mississippian refugia (McAllister and Lindsey 1961), although closer in anal ray 'branching' to the form that survived in Beringia. Unfortunately the preoperculum does not have characters known to assign it to one of those forms. However, one can say that very shortly after the glacier had left the Coppermine area, *Cottus cognatus* from one of these refugia had already entered the region. Arctic Charr in the Coppermine area today display a mixture of forms which survived in Beringia and the Atlantic coastal plain (McPhail and Lindsey 1970).

The bones are all derived from small individuals thus suggesting shallow water. Possibly the fish were caught in a drying sandy pool near the margin of a river or lake, or an eroding sandy river bank collapsed into shallow waters. The four species are freshwater dwellers; none except for the Arctic Charr are anadromous.

The fine state of preservation of the bones and their

high density in the matrix suggest that further research on the fauna would be worthwhile. Additional species of, for example, Salmonidae, Catostomidae, or Gadidae may be represented. Occurrence of adult scales or operculas may reveal growth patterns and life cycles.

L. D. Farley-Gill, Quaternary Paleoecology Laboratories, Geological Survey of Canada, kindly identified a piece of wood as willow. We thank the National Museum of Natural Sciences scientists Stephen L. Cumbaa for confirming the identification of the Arctic Charr dentary and C. Richard Harington for criticizing the manuscript.

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Received 30 June 1980
Accepted 12 September 1980

Gulls Robbing Prey from Great Blue Herons (*Ardea herodias*)

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Quinney, T. E., B. N. Miller, and K. R. S. Quinney. 1981. Gulls robbing prey from Great Blue Herons (*Ardea herodias*). Canadian Field-Naturalist 95(2): 205–206.

Three of five attempts by gulls to steal prey from adult Great Blue Herons (*Ardea herodias*) during 80 h of observation were successful. Over half of the aggressive actions involving adult herons were directed at gulls. Prey stolen were always longer than 140 mm. The handling times of these items indicates that herons have difficulty swallowing such large prey and thus become susceptible to piracy.

Key Words: Great Blue Heron (*Ardea herodias*), Great Black-backed Gull (*Larus marinus*), kleptoparasitism, handling time.

Kleptoparasitism, or piracy, is well documented in birds (Brockman and Barnard 1979). Gulls are commonly described as pirates (Lockley 1953; Meinertzhagen 1959; Hatch 1970, 1975; Morrison 1978), but Great Blue Herons (*Ardea herodias*) have seldom been described as victims of piracy (Carlsson 1979).

Gull–heron interactions were recorded during a study of the foraging behavior of Great Blue Herons (Quinney and Smith 1980). Herons on their foraging grounds in three estuaries of the Minas Basin, Nova Scotia (45° 08′N, 65° 16′W), were watched for 80 h 24 July – 17 August 1978. Up to 17 adult and newly fledged juvenile herons foraged concurrently in the numerous tidal pools and streams exposed during low tide in these estuaries. Great Black-backed Gulls (*Larus marinus*) and Herring Gulls (*L. argentatus*) were usually present and spent considerable time apparently loafing along the stream banks or on mud bars.

Adult herons performed inter- and intra-specific aggressive actions on 21 occasions (not involving captured prey). Eleven such events resulted when Great Black-backed Gulls attempted to approach too closely to feeding herons. Black-backs stole prey, in all cases Flounder (*Liopsetta putnami*) longer than 140 mm, from adult herons on three occasions. This size approximates the length of a male heron's bill (Godfrey 1966, p. 36).

The handling time of large (over 105 mm) compared with smaller prey indicates that adult herons have difficulty swallowing large prey (large: 52 s, $n = 12$, vs. smaller: 7 s, $n = 114$). Only 5% (13/279) of

all prey captured by adult herons were large. When a heron captured a large prey item and did not swallow it immediately, one or more gulls often quickly flew in. If the gulls came within 2 m, the heron partially extended its wings and lunged at the gulls, still holding the captured prey in its bill. The gulls retreated immediately about 5 m but continued to watch. If the prey was dropped during mandibulation, a gull often flew in, stole the prey, and flew away followed by other gulls. Conflict over the stolen prey often ensued. After a loss, the heron vocalized and lunged toward the thief for a few steps, but never flew in pursuit. An adult Herring Gull attempted twice to steal a large fish from a heron in flight, but failed.

The relatively low frequency of interspecific aggressive interactions and prey robbing involving gulls and herons indicates that the effect upon heron foraging is minor. Prey robbing by gulls appears limited to large prey that are captured infrequently and handled with difficulty by Great Blue Herons.

We thank P. C. Smith, J. A. Kushlan, R. D. Bayer, and J.-L. Des Granges for their comments on the manuscript. This study was supported by National Research Council of Canada grant A0236 to P. C. Smith, Canadian Wildlife Service, University Research Support Fund, and Federal Summer Job Corps project No. 16-01-003.

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Received 6 March 1980
Accepted 8 September 1980

First Record for Canada of the Bat Mite *Spinturnix globosus* and a New Host, *Myotis lucifugus*[1]

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Smith, Hugh C. 1981. First record for Canada of the bat mite *Spinturnix globosus* and a new host, *Myotis lucifugus*. Canadian Field-Naturalist 95(2): 206–207.

The first Canadian record for the bat mite *Spinturnix globosus* is documented from Little Brown Myotis, *Myotis lucifugus*, at four Alberta nursery colonies. This is the first report of the mite's occurrence on *Myotis lucifugus*.

Key Words: *Spinturnix globosus, Myotis lucifugus*, first record, host.

During the preparation of a series of Little Brown Myotis, *Myotis lucifugus*, as study skins, mites were noted in and around the anal orifice of several individuals. Five mites were collected and forwarded to the Biosystematics Research Institute, Agriculture Canada, Ottawa, for identification. There, Evert E. Lindquist identified these mites as adult female *Spinturnix globosus*. They represent the first record for this mite in Canada and the first time that *Myotis lucifugus* has been reported as a host (Whitaker and Nixon 1974). Other locality records for this mite are from Tennessee, Indiana, Utah, Arizona, Oklahoma (Rudnick 1960), Kansas (Ubelaker 1966), and Oregon (J. O. Whitaker, Jr., Indiana State University, personal communication). This mite has been reported on various species of bats: *Myotis sodalis* (Indiana Myotis), *Myotis velifer* (Cave Myotis), and *Myotis*

[1]Provincial Museum of Alberta Natural History Contribution 59.

grisescens (Gray Myotis) by Rudnick (1960), and *Myotis volans* (Long-legged Myotis) by Whitaker (personal communication).

Spinturnix globosus was originally described by Rudnick (1960) and was placed in the genus *Paraspinturnix*. Domrow (1972) subsequently synonomized it into its present genus *Spinturnix*. *Spinturnix globosus*, in common with all other members of the family Spinturnicidae, is exclusively parasitic on bats (Rudnick 1960). Rudnick (1960) noted that only the adult female of *S. globosus* has been recovered, and only in the anal orifice. But Ubelaker (1966) reported that this mite was obtained from the penis of a male and from the vagina of females of *M. grisescens*.

Spinturnix globosus were recovered from bats that were collected at four nursery colonies in Alberta in July 1978; and no attempt was made to obtain any specific age or sex cohort. No systematic search for parasites was made on all bats collected. The number of mites per bat ranged from one to three (Table 1).

TABLE 1—Incidence of infection with the mite *Spinturnix globosus* at four nursery colonies of Little Brown Myotis *Myotis lucifugus*, in Alberta (All female bats were adults; the male bat was a juvenile)

Location	Number of bats		Mites/bat
	Examined	Infected	
52°29′N–112°11′W	48	1 ♀	1
		8 ♀	2
		5 ♀	3
54°01′N–110°54′W	21	1 ♀	1
54°10′N–110°56′W	8	1 ♀	1
		1 ♀	2
54°11′N–110°48′W	33	1 ♂	1
		1 ♀	1
		1 ♀	2

Ubelaker (1966) reported that he found no more than three mites per host.

Bat ectoparasites, especially in Canada, are relatively poorly known. Rudnick (1960) suggested that the role played by blood-sucking ectoparasites should be included in the study of bat diseases. Recently in Alberta, as part of an overall rabies control program (see Dorward et al. 1977 re-rabies in Alberta), there has been a concerted effort to study the life history of bats. To my knowledge no studies of ectoparasites of these bats have been carried out.

I thank D. Schowalter for collecting the bats, Lorne Duncan and Anne Allen for preparing the specimens as study skins and for observing and collecting the mites, Evert E. Lindquist for identifying the mites and supplying requested literature references, and John Whitaker for bringing several pertinent references to my attention.

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Received 24 June 1980
Accepted 3 November 1980

Estimating Winter Defecation Rates for Moose, *Alces alces*

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Oldemeyer, John L., and Albert W. Franzmann. 1981. Estimating winter defecation rates for Moose, *Alces alces*. Canadian Field-Naturalist 95(2): 208–209.

The pellet-group count technique was tested for 2 yr in a 1.6-km^2 enclosure with known numbers of Moose (*Alces alces*) on the Kenai National Moose Range, Alaska. Pellet-groups were cleared from one hundred and sixty 17.8-m^2 quadrats each fall and counted and cleared from those same quadrats in the spring. Clearing of permanent pellet-group plots in fall is necessary for an accurate estimate of Moose numbers and winter use. In winter 1976–1977, seven Moose inhabited the enclosure and deposited a daily average of 16.2 pellet-groups per Moose. The next winter, six Moose deposited a daily average of 17.2 pellet-groups per Moose.

Key Words: Moose, *Alces alces*, Alaska, pellet-group counts, population size.

The pellet-group count technique (Neff 1968) has been used for estimating Moose (*Alces alces*) numbers and determining habitat preferences since the establishment of the Kenai Moose Research Center (MRC), Alaska, in 1968 (LeResche and Davis 1973; Franzmann et al. 1976b). They reported, however, that May counts of permanent plots in a 1.6-km^2 enclosure at MRC with known numbers of Moose resulted in unusually high daily defecation rates (20.2 groups per Moose in 1970–1971 to 28.7 groups per Moose in 1973–1974). To lend support to the apparent bias in the plot counts, Franzmann et al. (1976a) followed eight individual Moose during winter 1975, when snow cover allowed accurate counts of daily defecations, and found the daily defecation rate (and range) for adult cows was 14.6 (10–22) groups, that for adult bulls was 19.6 (14–25) groups, and rates were significantly different ($P < 0.01$) between sexes.

We assumed that the daily defecation rates from the winter-trailed Moose was a more accurate estimate of Moose defecation rates, even though the plot counts had been consistent over the years in their random distribution of groups within vegetative types and in relative Moose use among types. In the plot counts, the only variable not taken into consideration was summer-deposited pellet-groups. The objective of this study was to determine if the daily defecation rates obtained when plots were cleared in fall (to eliminate summer-deposited pellet-groups) and counted and cleared in spring were similar to the rates obtained by winter-trailing Moose.

Methods

In 1969, 160 permanent 17.8-m^2 (8 × 24 ft) plots were randomly located in the seven important upland vegetation types in the 241-ha Enclosure 1 at MRC. The plots were used for estimating plant utilization and for pellet-group surveys (R. Bishop. 1969. Moose Report. Alaska Department of Fish and Game 153 pp. (mimeo.)). Eighteen to 26 plots were located in each vegetation type without regard to type size. These 160 plots represented about 0.1% of the enclosure. Through spring 1976, pellet-groups were counted and removed from the plots in early May.

All plots were cleared of defecations in September 1976 before we began this study. Plots were counted and cleared in May 1977, cleared in September 1977, and counted and cleared in May 1978.

The counting procedure followed was as follows: A 7.3-m (24-ft) rope was strung between the two stakes placed at midpoints of the end of each plot. A 1.2-m (4-ft) width was walked on each side of the rope and in each direction so that the plot was counted twice. All pellet-groups in which the group center, or at least half of the pellets fell within the plot, were counted and removed from the plot.

As part of other studies at MRC, the number of Moose in the enclosures was closely monitored. In Enclosure 1, there were seven Moose providing 1722 Moose days between October 1976 and May 1977 and six Moose providing 1308 Moose days from October 1977 to May 1978.

Analysis of the data followed Bowden et al. (1969) in which the data were first tested for random deposition with the Poisson distribution.

Results and Discussion

The distribution of our data fit the Poisson distribution each year for all vegetation types except one. This implies random deposition of defecations within the enclosure, which we would expect in this area because snow is not deep enough to force yarding; topographic differences are not distinct enough to result in preferential use; and even in dense populations Moose tend to be solitary animals.

Analysis of variance of $\sqrt{x + 0.5}$ transformed

counts (to equalize variance) comparing mean number of pellet-groups per plot among types failed to show significant differences; therefore, we used a pooled total estimate of pellet-groups in the enclosure. There were 1722 d of use by seven Moose during the 1976–1977 winter and they deposited an average (± 95% confidence interval) of 16.2 ± 5.78 pellet-groups per Moose day. The next winter, there were 1308 Moose days and an average deposition rate of 17.2 ± 7.76 pellet-groups per Moose day. These rates are higher than most reported rates for Moose (Timmerman 1974) or for other ungulates (Neff 1968). The results for the two winters, however, are within the range (14.6–19.6) of that found by Franzmann et al. (1976a) when individual Moose were trailed in snow and represent the most controlled study of the technique for Moose defecation rates.

These rates are more realistic for Moose than those reported earlier (Franzmann et al. 1976b) and demonstrate the need to clear permanent pellet-group plots in fall if estimating Moose winter use or numbers. Neff (1968) has remarked on the lack of reliability of estimating age of pellet-groups, which reinforces the need to clear plots before the season of interest.

As an additional test, we estimated the number of pellet-groups Moose would have deposited in the enclosure over winter by multiplying the known number of male and female Moose days by the number of defecations per day.

Based on the data of Franzmann et al. (1976a), we calculated in winter 1976–1979 that there would have been 25 232 groups deposited by three adult males and three adult females. This value would leave 2791 pellet groups to be deposited by one calf resulting in a rate of 11.4 groups per day. In winter 1977–1978 there would have been 19 184 groups deposited by two males and three females leaving 3310 groups to be deposited by the one male yearling. The defecation rate for that animal would have been 15.2 groups per day to reach our sample estimated total of 22 494.

In summary, we have had an ideal opportunity to test pellet-group surveys for estimating Moose populations and habitat use. The estimated defecation rates of 16.2 and 17.2 groups per Moose day were well within the range observed for winter-trailed Moose and appear to be precise estimates of winter defecation rates.

In addition when comparing our results with earlier studies at MRC, we have demonstrated the need for clearing pellet-group plots in both fall and spring if one is to estimate winter use by Moose accurately. We would expect this practice to be a requirement for other western ungulates.

Acknowledgments

We thank C. J. Breckenridge. W. L. Regelin, and C. C. Schwartz for their field assistance. Daniel Welsh, Canadian Wildlife Service, provided constructive criticism of the manuscript. The project was funded in part by Federal Aid in Wildlife Restoration Project W-17-R.

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Received 22 August 1980
Accepted 27 November 1980

First Canadian Records of the Ghost Shiner (*Notropis buchanani*) and the Orangespotted Sunfish (*Lepomis humilis*)

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Holm, Erling, and George A. Coker. 1981. First Canadian records of the Ghost Shiner (*Notropis buchanani*) and the Orangespotted Sunfish (*Lepomis humilis*). Canadian Field-Naturalist 95(2): 210–211.

Ghost Shiners (*Notropis buchanani*) and Orangespotted Sunfish (*Lepomis humilis*), previously unknown from Canada, are apparently well established in the Thames River and Cedar Creek, respectively, in southwestern Ontario. The record for Ghost Shiners extends the known range into the Great Lakes drainage and 270 km north of the nearest record. The record for Orangespotted Sunfish extends the known range 44 km north of the nearest record.

Key Words: Ghost Shiner, *Notropis buchanani*; Orangespotted Sunfish, *Lepomis humilis*; range extension.

Notropis buchanani, the Ghost Shiner, and *Lepomis humilis*, the Orangespotted Sunfish, not previously reported from Canada, were captured in 1979 and 1980 in southwestern Ontario.

We caught nine *N. buchanani* on 3 June 1979 in quiet and turbid backwaters of the Thames River, near the mouth of Dolsen Creek, Kent County, Dover Township (42°20′11″N, 082°23′40″W). The shiners were seined from water less than 1 m in depth over a bottom of clay, silt, and detritus. The specimens, six females and three males, 36–43 mm TL, have been added to the collection of the Royal Ontario Museum (ROM 35794). Identification of these specimens has been confirmed by R. M. Bailey, University of Michigan Museum of Zoology (UMMZ).

Notropis buchanani is apparently common in the lower Thames. On 12 June 1980, we captured 86 fish at five of the six stations sampled from the Thames River below Kent Bridge (42°30′48″N, 082°04′15″W). At three locations, *N. buchanani* was more abundant than any other species. These specimens are catalogued as ROM 36436–36440. An additional 15 specimens were donated to UMMZ (207676).

The maximum size attained by *N. buchanani*, according to Trautman (1957), is 64 mm TL. The largest individual we captured was a female, 51 mm TL, full of eggs. Most of the males, the largest 43 mm TL, were tuberculate (see Cross 1967 for best description of tuberculation).

The habitat in the Thames River was similar to that described by Smith (1979) for this species, i.e., large rivers with turbid water and a soft bottom of silt and detritus. But Trautman (1957) stated that *N. buchanani* sought clear, quiet water with clean sand and a gravel bottom, and that it was apparently intolerant of turbidity and current.

Notropis buchanani is easily confused with the Mimic Shiner, *Notropis volucellus*, but differs in that *N. buchanani* rarely possesses an infraorbital canal, has more highly elevated anterior lateral line scales, and differs in pigmentation (see Bailey 1956 for best key).

Notropis buchanani was previously known to occur only in the Mississippi drainage. The new record is 270 km north of the nearest record in Ohio (Trautman 1957). Smith (1979) recorded the Ghost Shiner in the upper Illinois River near Morris, Illinois. The species has access to the Great Lakes via the Chicago Ship Canal, but there is apparently no record of this species in the Great Lakes system of Illinois or adjacent states (see Gilbert 1980). The Illinois record is 510 km west of the mouth of the Thames.

When one considers its abundance in the lower Thames, it is surprising that this shiner has been missed in past surveys. Because of its size, however, it would have eluded large-mesh nets, and according to ROM and the Ontario Ministry of Natural Resources records, there have been few small fish collections from the lower Thames. Stream characteristics may have discouraged seining in the past. *Notropis buchanani* may also have been regularly confused with *N. volucellus*, although a check of past ROM collections of *N. volucellus* from the upper Thames River did not turn up any *N. buchanani*.

We captured *L. humilis* on 11 June 1980 at two locations in Cedar Creek, Essex County, Colchester South Township (42°01′53″N, 082°49′53″W and 42°01′38″N, 082°49′27″W). Thirty-eight specimens, 36–97 mm TL, catalogued as ROM 36441 and 36442, were seined from shallow muddy water with a bottom of silt, clay, and detritus.

Lepimis humilis was the most abundant species comprising almost half of the total catch of several species. Eight specimens (51–58 mm TL) were females full of eggs. The two largest individuals (83 and 97 mm TL) were older males with enlarged ear flaps, and the remainder was smaller males and juveniles. One of the collections included four hybrids between the Pump-

kinseed and the Orangespotted Sunfish, *L. gibbosus* × *L. humilis*, 49–69 mm TL (ROM 36443), identified by intermediacy of diagnostic characters.

Lepomis humilis is distinguished from other *Lepomis* by a flexible opercle, greatly elongated preopercular sensory pores, and conspicuous orange (male) or brown (female) spots on the cheeks and sides (see Trautman 1957). Number of dorsal spines (10–12), dorsal soft rays (10–11), and anal soft rays (8–10) of the Cedar Creek individuals averaged higher than Kansas specimens (Cross 1967), the only specimens for which these values are given in the literature.

According to Trautman (1957), *L. humilis* was first recorded from the Lake Erie drainage in 1929 in Lake St. Mary's, Ohio, and spread rapidly northeastward. In 1952 the first specimens were captured on South Bass Island, Lake Erie, 44 km south of the present record. Specimens of *L. humilis* should be looked for in future surveys in the drainages of Lake Erie and Lake St. Clair because the range of this silt-tolerant species will likely continue to expand.

Acknowledgments

We thank E. J. Crossman for valuable help in the preparation of this note, R. M. Bailey for confirming the identity of the Ghost Shiners, and G. A. Goodchild for providing Ontario Ministry of Natural Resources fish survey records of Kent and Essex Counties.

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Received 28 August 1980
Accepted 8 December 1980

Reports of Significant Range Extensions

Range Extensions for 15 Teleost Fishes in the Hudson Bay Lowlands, Ontario

Osteoglossiformes: Hiodontidae: *Hiodon alosoides,* Goldeye
H. tergisus, Mooneye
Salmoniformes: Osmeridae: *Mallotus villosus,* Capelin
Cypriniformes: Cyprinidae: *Phoxinus eos,* Northern Redbelly Dace
Couesius plumbeus, Lake Chub
Notropis atherinoides, Emerald Shiner
N. cornutus, Common Shiner
N. heterolepis, Blacknose Shiner
N. hudsonius, Spottail Shiner
Pimephales promelas, Fathead Minnow
Semotilus margarita, Pearl Dace
Perciformes: Percidae: *Perca flavescens,* Yellow Perch
Etheostoma exile, Iowa Darter
E. nigrum, Johnny Darter
Cottidae: *Myoxocephalus quadricornis,* Four-horned Sculpin

As part of its Aquatic Habitat Inventory Program, the Ontario Ministry of Natural Resources (OMNR) has recently been systematically evaluating the resources of the Hudson Bay lowlands of Ontario. Between 1975 and 1979 surveys of the fish fauna have revealed range extensions for the 15 species of fishes listed. Sources used to define known ranges were Scott and Crossman (1973), Lee et al. (1980), and Ryder et al. (1964), as well as personal communications with scientists at the Royal Ontario Museum (ROM) and the National Museum of Natural Sciences (NMNS).

The sites where the fish were collected are shown in Figure 1. Details of the capture methods and habitats

TABLE 1—Range extension records for 15 species of fishes collected in the Hudson Bay lowlands of Ontario. Specimens were deposited at the Royal Ontario Museum (ROM) or National Museum of Natural Sciences (NMNS)

Location on map	No. of fishes	Fork length, mm	Date collected	Catalogue or accession no.	Extension of range, km
		Goldeye, *Hiodon alosoides*			
(17)	1	65	8 September 1976	NMNS 76-611	150 NE[b]
		Mooneye, *Hiodon tergisus*			
(16)	1	325	8 August 1976	NMNS 608	—[b,c]
		Capelin, *Mallotus villosus*			
(9)	1	118	3 July 1979	NMNS 79-966	160 SE[a]
		Northern Redbelly Dace, *Phoxinus eos*			
(8)	5	36–53	2 October 1978	ROM 3877	335 NNW[d]
(8)			1, 2 June 1979	ROM 3957	

TABLE I — *Concluded*

Location on map	No. of fishes	Fork length, mm	Date collected	Catalogue or accession no.	Extension of range, km
		Lake Chub, *Couesius plumbeus*			
(17)	4	37–57	17 June 1976	ROM 3129	170 NE[d,e]
(18)	3	52–73	7 June 1976	ROM 3129	165 NE[d,e]
		Emerald Shiner, *Notropis atherinoides*			
(17)	1	36	12 September 1976	ROM 3260	260 N[e]
(19)	1	85	5 June 1976	ROM 3129	165 N[e]
		Common Shiner, *Notropis cornutus*			
(8)	44	20–94	2, 9 October 1978	ROM 35739	250 N[f]
(8)			12 June 1979	ROM 36385	
		Blacknose Shiner, *Notropis heterolepis*			
(8)	6	35–42	2 October 1978	ROM 35743	300 NE[e]
(8)			2 June 1978	ROM 36387	
		Spottail Shiner, *Notropis hudsonius*			
(3)	1	58	14 August 1976	ROM 3268	240 NE[e]
(11)	21	26–98	5, 6 June 1978	ROM 3695	135 NW[c]
(12)	13	28–94	5 June 1978	ROM 35635	130 NW[e]
(2)	1	87	26 June 1978	ROM 35897	225 NE[e]
(13)	7	33–85	5 June 1978	ROM 35634	130 NW[e]
(4)	5	30–58	23, 24 July 1976	ROM 3263	230 NE[e]
(10)	10	19–101	18 July 1976	ROM 3263	180 WNW[e]
		Fathead Minnow, *Pimephales promelas*			
(8)	25	23–57	2 October 1978	ROM 35740	335 NNW[e]
(8)			1, 2 June 1979	ROM 36401	
		Pearl Dace, *Semotilus margarita*			
(6)	39	29–67	11, 19 June 1977	ROM 35089	140 ESE[d]
(8)	19	38–69	2 October 1978	ROM 35742	335 NNW[d]
(8)			1, 2 June 1979	ROM 36386	
		Yellow Perch, *Perca flavescens*			
(7)	1	250	15 August 1979	NMNS 79-965	435 E[b]
(11)	3	46–57	5, 8 June 1978	ROM 3695	380 ESE[e]
(12)	5	41–57	5 June 1978	ROM 3695	175 NNW[e]
(13)	2	44–79	3, 5 June 1978	ROM 3695	175 NNW[e]
(1)	34	40–47	21, 22 August 1977	ROM 3566	275 NE[e]
(10)	29	34–93	15, 16 July 1976	ROM 3846	200 WNW[b]
		Iowa Darter, *Etheostoma exile*			
(3)	1	50	27 June 1978	ROM 3263	720 NNW[e]
(5)	5	26–31	16 August 1976	ROM 3846	700 NWW[e]
(2)	2	31–38	21, 26 August 1977	ROM 35898	720 NWW[e]
(13)	1	35	5 June 1978	ROM 3695	330 NW[e]
(8)	1	31	2 June 1978	ROM 36384	340 NNW[e]
		Johnny Darter, *Etheostoma nigrum*			
(17)	2	38–54	17, 23 June 1976	ROM 3129	180 SE[e]
(14)	1	28	30 October 1976	ROM 3264	135 SSE[e]
(15)	19	26–60	August–October 1975	ROM 2437	140 SSE[e]
(8)	6	29–63	2 October 1978	ROM 3877	70 SSE[e]
(8)			1, 2 June 1979	ROM 36389	
		Four-horned Sculpin, *Myoxocephalus quadricornis*			
(18)	1	44	12 September 1976	ROM 3263	275 SE[a]
(14)	1	180	5 October 1976	NMNS 76-612	235 SE[a]
(8)	1	150	2 October 1978	ROM 35738	160 SE[a]

[a]Southernmost record in James Bay.
[b]Not previously recorded within lowlands in this watershed.
[c]Previous record from this location disputed (Dymond 1937).
[d]Caught in area that at times is within tidal salt water influence.
[e]Not previously recorded in this watershed. Isolated by salt water from previous record.
[f]Not previously recorded in Hudson Bay drainage in Ontario.

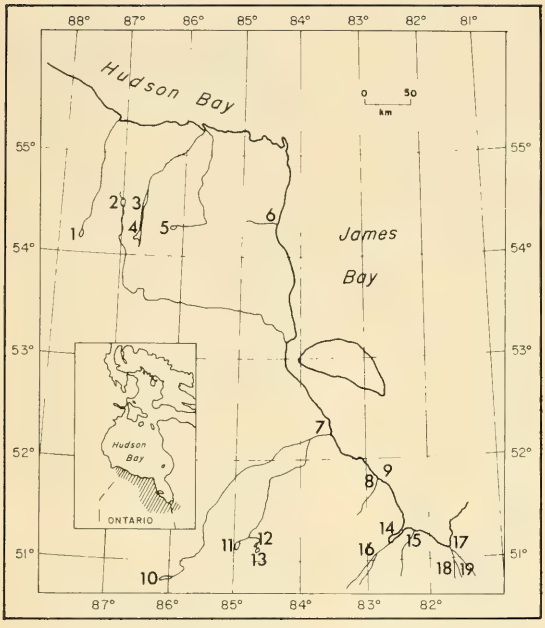

FIGURE 1. Sites where fishes were captured within the Hudson Bay lowlands of Ontario. Inset delimits extent of the lowlands in the province. Collection sites were as follows: 1, Shamattawa Lake (55°10′N, 58°41′W); 2, North Washagami Lake (54°31′N, 85°03′W); 3, Hawley Lake (54°31′N, 84°38′W); 4, Sutton Lake (54°16′N, 84°42′W); 5, Kinusheo Lake (54°16′N, 84°11′W); 6, Lakitusaki River, (54°22′N, 82°29′W); 7, Albany River (52°13′N, 81°36′W); 8, Wapiskau River (51°51′N, 80°47′W); 9, James Bay (51°53′N, 80°45′W); 10, Trilsbeck Lake (50°48′N, 84°02′W); 11, Jaab Lake (51°09′N, 82°58′W); 12, North Sandbank Lake (51°08′N, 82°42′W) — not listed in Gazetteer of Canada (Ontario); 13, Sandbank Lake (51°06′N, 82°42′W); 14, Moose River (51°14′N, 80°38′W); 15, Partridge River (51°19′N, 80°19′W); 16, Abitibi River (51°04′N, 80°55′W); 17, Harricanaw River (51°10′N, 79°47′W); 18, Kesagami River (51°08′N, 79°47′W); 19, Kattawagami River (51°04′N, 79°44′W).

are available from the Ontario Ministry of Natural Resources (Box 190, Moosonee, Ontario P0L 1Y0). We have summarized information on the 15 species in Table 1 including the approximate distance and direction of our new records from the closest previously recorded localities. The range extensions are from 70 to 720 km.

Individuals who assisted us in our collections or from whose collections the records are drawn are T. Archibald, T. Bellhouse, T. Edwards, D. Fletcher, F. Johnson, R. Stitt, G. Sudbury, and J. P. Prevett who also assisted with the preparation of the manuscript. Specimens were identified by D. E. McAllister of NMNS or one of the following OMNR staff: G. C. Gillespie, E. Holm, F. Johnson, and O. C. O'Neil. Collections were funded by OMNR with assistance by a grant from the Federal Industrial Development Agency.

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Received 14 April 1980
Accepted 18 November 1980

News and Comment

Editor's Report for 1980

During 1980 the manuscript flow for *The Canadian Field-Naturalist* was similar to that of the previous year. Table 1 summarizes the numbers of manuscripts accepted for publication with respect to the numbers submitted in any given year. Note that the figures for accepted manuscripts for recent years are not final as some manuscripts will still be revised and published.

TABLE 1—Statistics on manuscripts submitted and accepted to the end of 1980

Year submitted	Number of manuscripts	
	Submitted	Accepted
1973	153	117
1974	152	116
1975	167	122
1976	147	93
1977	137	88
1978	149	91
1979	148[a]	90
1980	137[a]	47

[a]Includes four manuscripts not formally refereed: one Viewpoint and three papers from The Ottawa Field-Naturalists' Club Centennial Symposium.

Volume 94 (1980) of *The Canadian Field-Naturalist* contained 93 scientific papers (48 Articles and 45 Notes). Table 2 gives the breakdown according to subject matter; this is similar to those of previous years. I hope that the publication of the first of the "Reports of Significant Range Extensions" will encourage others to contribute to this annotated list. Although I originally proposed to publish them as an annual list, these range extensions will now, until circumstances change, appear in the next available issue of the journal.

TABLE 2—Number of manuscripts published in *The Canadian Field-Naturalist* in 1980 with respect to field of study.

Subject	Number of manuscripts	
	Total	(Articles + Notes)
Birds	31	(18 + 13)
Mammals	27	(12 + 15[a])
Plants	19	(10 + 9)
Fishes	5	(3 + 2)
Amphibians and Reptiles	5	(3 + 2)
Invertebrates	4	(0 + 4)
Other subjects	2	(2[b] + 0)

[a]Includes one Note under the heading *Reports of Significant Range Extensions.*
[b]Includes a Viewpoint.

The Business Manager, W. J. Cody, has supplied some figures on the current mailing list of *The Canadian Field-Naturalist*, and these are included as an item of general interest in Table 3. The data indicate that the journal receives a wide national and international distribution both to individuals and institutions (including libraries). Besides addresses in Canada and

TABLE 3—Current (1980) geographic distribution of recipients of *The Canadian Field-Naturalist*

Area	Club Memberships[a]	Individual subscribers	Institutional subscribers	All recipients	
				Number	(%)
Canada					
Maritime provinces	40	30	36		
Quebec	68	18	43		
Ontario	832	105	128	1735	(77.3)
Prairie provinces and territories	135	114	85		
British Columbia	46	32	23		
United States	103	66	272	441	(19.6)
Other countries	7	9	54	70	(3.1)
Total number (%)	1231[b] (54.8)	374[c] (16.7)	641[d] (28.5)	2246	(100)

[a]Includes Family Memberships.
[b]Includes copies to 15 Honorary Members and to the club's patrons.
[c]Includes seven copies for journal personnel.
[d]Includes 13 copies to depository libraries and abstracting and indexing services.

the United States, the journal is mailed to the following countries: Australia, Belgium, Brazil, Czechoslovakia, Denmark, Finland, France, West Germany, Iceland, Jamaica, Japan, Mexico, Netherlands, New Zealand, Norway, Panama, Peoples Republic of China, Poland, St. Pierre and Miquelon, South Africa, Sweden, Switzerland, United Kingdom, and USSR.

This year we especially express our appreciation to Marilyn Dadswell for her seven years of dedicated copy-editing. At the same time we welcome Patricia Lalla to fill the void created by Marilyn's retirement. My personal thanks are also extended to my editorial colleagues, to the Production Manager, to the Business Manager, and to our many willing referees, all of whom assist substantially in maintaining standards or otherwise help with the publication of interesting papers pertinent to the natural history of Canada.

LORRAINE C. SMITH
Editor

A New National Wildlife Area — Long Point in Lake Erie

The donation of the major part of Long Point in Lake Erie, the largest unspoiled sand dune – marsh land complex in the Great Lakes, was made to the people of Canada by the Long Point Company and the Nature Conservancy (U.S.). Except for small pieces of the point, the land had belonged to the Long Point Company since 1866. Now under the management of the Canadian Wildlife Service of Environment Canada, Long Point becomes one of 39 National Wildlife areas under the Canada Wildlife Act.

Long Point, a 32-km-long sandy spit, juts into Lake Erie, south of Simcoe, Ontario. As one of Lake Erie's three major points (the others being Point Pelee National Park and Rondeau Provincial Park), it serves as a resting or nesting stop for 150 species of birds and is considered vital for maintaining certain bird populations at healthy levels. A significant portion of the world's population of Redhead and Canvasback ducks and Whistling Swans pass through Long Point each year. In addition to migrating birds, Long Point is important for bats and butterflies that traverse Lake Erie. They funnel through the area because it is the first point of land encountered on northward spring migration and the most southerly point for their fall movement.

The vegetation on Long Point is unusual because it is of a type usually associated with the middle-eastern United States. Also the ridges and valleys of the sand dunes create an intriguing juxtaposition of different plant communities. The older ridges contain mature forests while savannas predominate near the younger tip of the point. At least five rare or threatened species of amphibians and reptiles are found on Long Point.

Because of the care and foresight of the Long Point Company, Long Point exists today in its wild state as valuable wildlife habitat.

Canadian Wolf Status and Conservation Strategy Workshop

A workshop on wolf conservation problems in Canada will be held 12–14 May 1981 in Edmonton, Alberta. The purpose of the workshop is to review the status of the species in Canada, and to map out a conservation strategy based on sound technical information. This will lay out the groundwork for the species' survival into the 21st century.

Emphasis of the workshop will be on the guidelines provided by the International Union for Conservation of Nature and Natural Resource (IUCN) on World Conservation Strategy. The conservation strategy focusses on the preservation of genetic diversity and it endeavors to ensure sustainable utilization of species and ecosystems.

The participants already confirmed will deliver papers on the following topics: IUCN perspective, wolves and ungulates, wolves and livestock, wolf taxonomy, and general papers including ones on wolf management.

The proceedings of the workshop will be published.

For further information please contact Dr. L. N. Carbyn, Canadian Wildlife Service, 9942-108 Street, Edmonton, Alberta T5K 2J5.

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The Ontario Field Biologist

The Ontario Field Biologist is a semiannual natural science journal of the Toronto Field Naturalists, which has been published regularly for over 25 years. Articles and notes dealing with amateur and professional research in all aspects of natural history are published in it. It fills a role between the senior scientific journals and club publications, and hence provides a vehicle particularly for amateur papers of merit. Emphasis is on Ontario subject matter, and all papers are subject to review. Topics in the last two years include a monitoring survey of winter birds in Wellington County, Ontario, Ontario's pondweeds, a review of the status of the Greater Black-backed Gull on the Great Lakes, Tremblay's Salamander in Algonquin Park, and notes on the flora of the Canadian portion of the Niagara frontier. Subscriptions are available ($4.00 a year) from the Toronto Field Naturalists, 195 Glengarry Avenue, Toronto, Ontario M5M 1E1.

Submitted by Clive Goodwin

The Wilson Ornithological Society Annual Meeting

The 61st annual meeting of The Wilson Ornithological Society will be held at Sackville, New Brunswick, Canada, on 4–7 June 1981. The meeting will be hosted by the Canadian Wildlife Service — Atlantic Region, the Biology Department of Mount Allison University, and the Chignecto Naturalists' Club. Information concerning accommodations, transportation, excursions, and related matters, and a call for papers will be mailed to the membership in early March 1981. The deadline for submission of abstracts will be 15 April 1981. Chairman of the local arrangements committee is Dr. Anthony J. Erskine, Canadian Wildlife Service, P.O. Box 1590, Sackville, New Brunswick, Canada E0A 3C0.

Book Reviews

ZOOLOGY

A Bibliography of British Columbia Ornithology, Volume I

By R. Wayne Campbell, Harry R. Carter, Christopher D. Shepard, and Charles J. Guiguet. 1979. British Columbia Provincial Museum Heritage Record Number 7, Victoria. 185 pp., illus. $4.00.

The compilation of a bibliography is among the most time-consuming and frustrating tasks facing any scientist. The literature is usually scattered widely and contains many references published in obscure places, making the compilation of a complete bibliography an unrealistic goal. Yet, even a poor bibliography is useful to others. This volume is an excellent beginning on a bibliography to British Columbia birds. Although not stated anywhere in the book, the designation as Volume I in the title indicates that at least a second volume is planned.

The book consists of a short introduction, a list of sources searched, an explanation of format, acknowledgments, a bibliography of 2100 references, and indices to species, geographic areas of the province, and authors. Although the authors state that books and notes on single observations are not included, they presumably mean non-bird books with some bird data or large regional works, which include British Columbia, as several bird books are included. Similarly, many notes documenting single sightings out of range are included, and the authors apparently mean that they have excluded short notes on common birds in an area, such as may occur in local newsletters. Many theses and government reports are included, a feature of particular value to researches, as these are the sort of reports that are especially difficult to track down.

The list of sources searched is extensive, although some obvious journals, such as *Audubon Field Notes — American Birds*, covering North America as a whole, and others, such as *Western Birds*, covering the west coast, including British Columbia, specifically have not yet been included. Presumably these have been reserved for Volume 2. Some papers, of which the senior author has a copy, are excluded, presumably until the next volume.

The references are listed in the "order received," and not in any particularly useful sequence. However, the three useful indices give easy access to the papers by species, author, and area. Distinct races, until recently considered full species, are not listed separately in the species index, nor are hybrids. A few references perhaps should have included brief annotations to indicate their relevance to British Columbia where titles seem to indicate otherwise (e.g. "First Alberta record of the Glaucous-winged Gull"). The book is remarkably free of errors — I detected only "Porchard" for Pochard (p. 135) — and is produced well with attractive drawings, by an anonymous artist, interspersed throughout. Ornithologists in British Columbia and the entire west coast of North America will find this a very valuable document. When Volume 2 is complete, few will need to do more than consult these books and search subsequent literature when compiling available data on an ornithology subject within British Columbia.

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Population Ecology of Raptors

By Ian Newton. 1979. Buteo Books, Vermillion, South Dakota. 399 pp., illus. U.S. $35.

At last a book on raptors which is not simply a rehash of previously written books on this subject! This latest book by Ian Newton (his first was on finches in 1972) will surely have great impact on the thought processes of not only today's raptor enthusiasts, but wildlife ecologists in general. On page 13, he states his objectives which are to organize and interpret critically existing knowledge on population regulation of raptors and to present this synthesis in a simple informative manner for maximum benefit to professional and amateur alike. Newton succeeds in a most admirable way and leaves very few stones unturned, indeed.

The presentation of the information contained in the book is best described in the author's own words on page 16: "The first two chapters . . . deal with the social organisation and spacing behaviour of raptors, and the next two with density regulation. There are then five chapters on various aspects of breeding, two on movements, one on mortality, and three on the effects on raptor populations of human persecution, organo-chlorine chemicals, and other pollutants, respectively. Lastly, there are two chapters dealing with conservation management and captive breeding." The book deals virtually with the diurnal raptors or the Falconiformes.

I personally found the book extremely useful in two ways. First, by accumulating and synthesizing the vast

wealth of raptor literature, including his own intensive research on British Sparrow Hawks and Peregrine Falcons, the author has been able to draw certain conclusions about population regulation of raptors. Previously, most of these generalizations were no more than mere gut feelings on the part of scientists, but never substantially proven. Secondly, Newton offers much food for thought in his book by providing his own theories and speculations in this field. Most are based on no more than good common sense, but nevertheless are just begging to be studied. For example, on page 177, the author points out the scarcity of long-term studies involving marked birds.

With regard to the layout, I found the presentation of the tables (68 of them) at the back of the book instead of interspersed throughout the text rather bothersome, but admittedly, the author did a fine job of summarizing them in the written text. I especially liked the short summary presented at the end of each chapter.

The ink drawings by Jim Gammie introducing and occasionally closing each chapter are superb. The black and white photographs selected from various photographers add to the book's appeal, as they were obviously selected with quality in mind. Also clearly presented throughout the text in an informative supportive style are 50 graphs. All in all, the drawings, photographs, figures, lists of tables and figures, bibliography, index, and general lack of typographical errors indicate that this book was written and published with professionalism in mind.

This book is an absolute must for any conscientious, self-respecting, wildlife, population ecologist, particularly one who shares an affinity for birds of prey.

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Love Affair with a Cougar

By L. Hancock. 1978. Doubleday Canada Ltd., Toronto. 252 pp., illus. $9.95.

Love Affair with a Cougar is a detailed and tiring account of Lyn Hancock's experience raising orphaned cougars in southwestern British Columbia. The story follows the development and fate of four cougar kittens. Interspersed throughout the story are discussions of care and handling of cougars, public image of cougars, human–cougar interactions, and the social—political problems of keeping wild animals.

The pace of the book is very sluggish. Descriptions of the author's relationship with the litter, her reunions with one of the cougars after it had been placed in a local zoo, and the interactions between the cougars and the author's students are redundant and laborious to read.

I disagree with the author's use of her animals as representatives of the wild cougar population because they were heavily conditioned to the human environment. "Only by constant association and a buildup of mutual trust could we hope to maintain the friendship between ourselves and the cougars as they continued to develop." p. 145. The discussions of the domestic relationship between humans and cougars offered little convincing evidence of a wild cougar's behavior.

The downfalls of the book could have been eliminated by strict editing. The interesting parts of the book would then have been easier to appreciate.

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Camel Quest

By Anne Innis Dagg. 1978. York, Toronto. 150 pp., illus.

Anne Dagg recounts a journey that she and a colleague, Hilde (whose last name is never revealed), embarked upon to study camels in Mauritania, a small Islamic Republic bounded in the west by the Atlantic Ocean, in the south by Senegal, in the east by Mali, and in the north by Algeria. The southern part of the country is savanna grassland and the northern part, Sahara Desert. About 80% of the 1 million inhabitants are Moors, a people of mixed Berber and Arab blood.

It all began in Calgary, Alberta, in 1971, when she attended a lecture that Hilde presented at a conference on ungulate behavior. Dagg, because of her interest in African mammals, found herself intrigued by Hilde's

lecture which focused on the biology of camels. She had earlier carried out studies for her doctorate, which concentrated on the locomotion of giraffes, in eastern Transvaal of South Africa. Subsequently, she wanted to study the camel, the only other large mammal that could survive on thorny vegetation for extended periods without drinking water, but to her dismay lacked the funds.

Hilde, a French biologist, who had spent time in Mauritania studying camel physiology, wanted to return there, and hence a trip was planned. Dagg went to study camel locomotion, and Hilde the vegetation surrounding wells utilized by the camels and their nomadic owners. At the time of their visit, Mauritania was being ravaged by drought. Many of the free-roaming camels were dying off, and many of the nomads had been forced to migrate to the Spanish Sahara where they could obtain food and water. Unfortunately, their camels were left in the desert to fend, usually unsuccessfully, for themselves.

In addition to their biological work, Dagg and Hilde decided to seek out and study the Reguibat "... the greatest camel men and perhaps the last truly free people of the world who had once reigned in the western desert as far south as Timbuctoo and as far north as Spain." Should this way of life disappear forever, Hilde felt it important that it be documented for the archives.

In this volume are tidbits of information about the camel, but emphasis is placed more on Dagg's experiences. It is an informal analysis of the nomadic way of life, a description of the various people encountered throughout their journey, and a review of the climate and terrain of the country. The book is of a socio-anthropological slant. If you are interested in Mauritania, then the volume will serve as introductory reading.

The book is tainted in some sections by certain remarks that only serve to detract from the story. For example, "... I was associated as a researcher with the Department of Biology at the University of Waterloo, Canada, but none of the other biologists, all men, cared to discuss the ecology of animals in Africa." Undoubtedly, too, there are many women biologists in this country who would not be interested in African animal ecology.

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Charrs: salmonid fishes of the genus *Salvelinus*

Edited by Eugene K. Balon. Dr. W. Junk bv Publishers, The Hague, The Netherlands. 928 pp., illus. U.S. $210.

This monograph provides a broad summary of our knowledge of the charrs, by 40 contributors from Europe, Asia, and North America. It is a landmark in the history of charr research. The 30 chapters are grouped into four parts: I. Review of the main forms; II. Taxonomy, biogeography, phylogeny, and morphology; III. Ontogeny, ethology, physiology, and ecology; and IV. Utilization of charrs by man and the creation of a new taxon.

Lionel Johnson, in an excellent chapter in Part I on the Arctic Charr, conveys the impression of the immense variability of this circumpolar species, for example, the frequent occurrence in Europe of dwarf and normal-sized populations, of spring and fall spawners, river and shallow or deep lake spawning, possession of several patterns of life cycles with varying stays and sequences in sea, lakes, and rivers. The chapter by R. H. Armstrong and J. Morrow shows Dolly Varden Charr have equally variable life history patterns. These authors also inform us that J. D. McPhail's western Arctic–Bering Sea form of Arctic Charr is in reality a northern form of Dolly Varden. This redefinition of the Dolly Varden is based on discriminant function analysis (DFA) of gill raker, vertebral, and pyloric cecal counts. Unfortunately the calculated weights for the characters are not given, so other workers cannot use their results for identification. However, assuming samples are adequate, the graphs convince one that there are three groups: Arctic Charr, northern and southern Dolly Varden, and that multivariate analysis is a useful approach in this difficult group.

The chapter on the Brook Charr emphasizes physiology as well as life history. Valuable information is given on the effects of pH on the life cycle of Brook Charr. Distressingly, the range of Brook Charr is decreasing in parts of the United States because of developmental pressures. It is also suggested that angling has selected for short life span and small size in the eastern United States.

Ksenia Savvaitova provides an overview of charr taxonomy in the Palearctic, valuable because of the number of charrs that have been described there, often in journals not generally available. Several charrs described from the Taimyer, USSR, are synonymized following unclear reasoning. She does not seem to

consider occurrence of sympatric reproductively isolated populations as species and presents much theory but little actual data on individual taxa. Mednikov et al., applying the technique of DNA hybridization, concluded that all Eurasian charrs should be regarded as *S. alpinus* except *S. leucomaenis*. Other papers in this volume affirm and provide evidence for the distinctiveness of *S. malma* and *S. alpinus*, but Savvaitova relegates these to 'malmoid,' 'alpinoid,' and 'high arctic' forms. This approach should be contrasted with Cavender's, who discovers, clearly describes, and illustrates new morphological characters for charr phylogeny (comparative morphology *lives*), and Morrow's multivariate analysis.

Robert Behnke was given the difficult task of discussing taxonomy of the genus *Salvelinus*. This genus he divides into three subgenera. In the subgenus *Salvelinus*, he recognizes *S. alpinus, S. malma, S. confluentus, S. profundus* (Bodensee, Europe), *S. taimyricus* (Taimyr, USSR), the unnamed stone charr (Kamchatka), and *S. leucomaensis* (western Pacific). He considers Morrow's *S. anaktuvukensis* to represent only northern Dolly Varden populations in small stream habitat in the Alaskan Brooks Range. Cavender, unlike Behnke, recognizes *S. pluvius* (Japan) as a distinct species. Only one species is recognized in the subgenus *Cristivomer, S. namaycush*. Two species are recognized in *Baione*, the Brook Charr, *S. fontinalis*, and the Silver Charr, *S. agassizi* (Dublin Pond, New Hampshire). The latter, unrecognized by the American Fisheries Society list of fishes (in press), is nevertheless well distinguished by its low gill-raker count (14–17), the raker's knob-like form, and the high number of pyloric ceca (43–58). The Silver Charr is believed extinct. A comparative table of characteristics of each species would not have been difficult to compile and would have been very useful.

Balon's five chapters on ontogeny of charrs wisely includes provenance and descriptions of parents. No evidence is provided for the suggestion in the title of Part IV that a new species of charr has been created (by hybridization of the Brook and Lake Charrs).

Many of the color photos of fish are excellent, but rather small. Some illustrations are poor, the symbols on the Arctic Charr distribution map are unreadable, the American range of the Lake Charr is omitted on the Lake Charr map. Otherwise the graphs, photos of embryos, histological sections, and osteological figures are generally of high quality.

The authors and editor have had a formidable task in just assembling the material, let alone digesting and drawing generalizations from it. But, aside from Behnke's paper, there is little cross referencing between chapters. There is no overview of how species differ in response to their environments, nor on comparative adaptations of planktivores and predators to their ways of life. No advantage was taken of the opportunity to use the assembled information at another level. Nevertheless, the editor and the contributors are to be congratulated for the general excellence of the book. There are few typographical errors.

Charrs provides a good summary of new and previously available but scattered information. The book will be essential for researchers specializing in the genus *Salvelinus* and a useful resource book for those having occasion to manage or investigate one or more species. Invaluable although it is, the price puts the volume beyond the budgets of most individuals and some institutions.

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The Evolution of Culture in Animals

By John Tyler Bonner. 1980. Princeton University Press, Princeton. 216 pp. $17.00.

Sociobiology is a hot topic and Bonner is both an erudite biologist and an articulate author. It is therefore no surprise that a book on this topic by this author is a pleasure to read. In eight chapters he surveys the biological background for cultural evolution. The work is intended as a personal document examining issues between the biological and social sciences, while avoiding political issues, for a broad audience. The central thesis is that the ability for culture, taken as the transfer of information by behavioral means, is an evolutionary product. After due attention to problems such as nature versus nurture, reductionism versus holism, and anthropomorphism, Bonner contrasts genetical and cultural evolution and examines the resulting interactions. The functioning of the brain, the eventual agent of culture, and of genes, especially in behavior genetics, are discussed, along with the time and size scales for different processes. The biological steps toward culture are presented: the evolution of motility, of societies (bacterial, insect, and vertebrate), of communication systems, of learning and teaching, and of behavioral flexibility in higher vertebrates. The discussion includes the differences in the evolution of sociality and of culture, and the advantages of both various

sensory modalities for complex communicatory signals and sociality under what Bonner terms communal task selection, by which he means selection for cooperation to perform tasks unachievable by individuals. In the final chapter, instances of nonhuman and human cultures, the adaptiveness of cultures, and the evolutionary trend to flexibility are surveyed. The cultural passage of memes, or ideas, between individuals is analogized with the genetic transmission of genes across generations. As in so much of contemporary evolutionary thinking, the importance of the contributions by W. D. Hamilton on kin selection and J. Maynard Smith on evolutionarily stable strategies is very obvious throughout the discussion. In keeping with his uniformitarian stance, Bonner has provided an excellent perspective of the long biological progression underlying cultural evolution.

With a very few minor blemishes, the book is well composed and illustrated and in these respects appropriately provides the impression of being a lighter version of E. O. Wilson's hefty "Sociobiology." The explanatory footnotes are helpful, although a few more (e.g. on Fisher's Fundamental Theorem) would assist "the well-read layman" of the intended audience. The calm and friendly style also enhance the attractiveness of the volume. The avoidance of political issues doubtless contributes to this calm, but it is nonetheless strange that Bonner should regard a discussion of the stability of recent Western sex role changes as a topic beyond the scope of the book. The need for the lengthy review of motility in lower forms, long one of Bonner's research interests, is doubtful, even allowing for the deep perspective he wishes to illustrate. On the other hand, given that, as Bonner argues, brains have succeeded in bypassing genes, it seems worthwhile to speculate on the possibility of computers bypassing brains. Similarly, a couple of mentions of "the evolutionary scale" and the lack of discussion of Lamarckism are perhaps surprising, although Bonner's Princeton predecessor, Baldwin, and his effect are mentioned. But such questions of emphasis are rarely decidable and the criticisms are minor. Overall this is an excellent volume as an introduction to the topic.

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BOTANY

The Whole Fungus: the sexual–asexual synthesis

Edited by Bryce Kendrick. 1979. Co-published by National Museum of Natural Sciences, National Museums of Canada, and the Kananaskis Foundation. 2 volumes, 793 pp., illus. Paper bound; available by mail from W. B. Kendrick, Department of Botany, University of Waterloo, Waterloo, Canada N2L 3G1.

The covers and spines lack the subtitle, and the half-title pages of both volumes bear a different subtitle — 'Kananaskis II.' The 27 chapters represent reports on papers either presented at the conference held in Kananaskis, Alberta, in 1977, or submitted for publication at the editor's request. Dialogues by participants follow each presentation. A postcript, a list of about 2000 references, and an index completes Volume 2.

The aim of the book is to present 'the sexual–asexual synthesis,' and 'to unite the different phenotypes, at least conceptually, and to use all of the data thus made available in the elaboration and refinement of our classificatory schemes.' For over a century mycologists have been concerned with the fact that fungi can be pleomorphic: Ascomycetes, Basidiomycetes of various kinds, and some so-called 'Phycomycetes' produce a sexual state and one or more kinds of asexual states. Independent names have been applied to such various states and mycologists have concerned themselves with connecting one state with the other(s). A chapter on 'Pleomorphism of fungi as treated in the history of mycology and nomenclature' is an excellent introduction to the problems involved. Three useful new terms — *anamorph* for imperfect (asexual) state, *teleomorph* for perfect (sexual) state, and *holomorph* for the whole fungus are used: the terms are explained in a chapter reprinted from *Mycotaxon* (6: 207–211. 1977). Five chapters are devoted wholly or in part to problems associated with the nomenclature primarily of pleomorphic ascomycetous fungi.

The main thrust of the book is found in several well-illustrated and documented chapters on anamorph-teleomorph connections in specific groups of fungi — Plectomycetes, nectrioid fungi, some freshwater Hyphomycetes, some Coelomycetes, in ascomycetous and so-called basidiomycetous yeasts, Agaricales and other Basidiomycetes (excluding Uredinales and Ustilaginales), and in Zygomycetes. There is a 'Classification of Ascomycetes partly based

on their anamorphs' and a chapter on 'Deuteromycetes and their relationships' which includes a classification of Deuteromycetes.

The largest chapter is a compilation, from the literature, of teleomorph–anamorph connections in unitunicate and bitunicate Ascomycetes which are listed alphabetically by generic name of the teleomorph. The records are then listed under the orders and families of the teleomorph. Unfortunately the extent of the literature search is not mentioned.

Records of teleomorph–anamorph connections vary in their reliability for several reasons. Apart from the basis for claiming a connection, a subject which is discussed in the book, there are also problems of the generic dispositions of teleomorph and anamorph(s). For instance, in *Melanomma* three species are listed with apparently related pycnidial anamorphs whereas a fourth species has an entirely different hyphomycetous anamorph. The four connections were established by ascospore isolations. If we accept the identifications and connections as correct, then it is likely that the teleomorph of the fourth entry, *M. subdispersum*, is not a *Melanomma*.

The chapter on an appraisal of the taxonomic significance of some modes of conidium ontogeny, and discussions on the same topic elsewhere, serve to remind us that so much remains to be done in the classification of anamorphs. But it is evident that the refinement of schemes of classification of both morphs must proceed together.

In a brief review it is impossible to cover the whole book composed for the most part of different approaches to essentially the same problems and goals. But this is its strength.

A few chapters, such as 'the classification and nomenclature of fossil fungi,' are lucidly written but are, I believe, somewhat on the fringes of the stated aim of the book.

The checking of several citations amongst the compilation of 'Teleomorph–anamorph connections in Ascomycetes' of particular interest to the reviewer has revealed several errors. For example, '*Torulopsis*' (pp. 380 and 387) should be '?*Torulopsiella.*' '*Capnocybe,*' in the reference(s) given, was not included as an anamorph of *Limacinia moniliformia* and *L. quinqueseptata* (p. 374), or of *Ophiocapnocoma* sp. (p. 380). The entry of '*Phoma herbarum*' as an anamorph of *Pleospora herbarum*, with the notation '2.3.1' to indicate considerable evidence of affiliation, is not substantiated in the references given, including 'Wehmeyer (1961)' which is not found in the references. On page 362 it is stated that 'Spegazzini never illustrated his papers' yet his 'Fungi Chilenses' alone has 130 text figures.

The book brings together a considerable amount of information and should be available particularly to those involved in the taxonomy, classification, and nomenclature of Ascomycetes and Fungi imperfecti, as well as of Agaricales and most other Basidiomycetes in pure culture.

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Grasses of Ontario

By W. G. Dore and J. McNeill. 1980. Agriculture Canada Research Branch Monograph 28. Supply and Services Canada, Ottawa. 566 pp. $12 in Canada; $14.40 elsewhere.

Dore and McNeill's *Grasses of Ontario* is likely to become the standard taxonomic treatment of central North American grasses and to remain so for some time. There are several reasons for this. Firstly, some 270 species in 78 genera are treated, representing the large majority of grasses native to the Great Lakes area; secondly, the taxonomic scholarship of the authors renders the work highly reliable. In this respect, the treatment of *Panicum*, for instance, represents an entrée into a difficult genus that possesses numerous species southwards, many very similar to Ontario species. To have the former eliminated instead of attempting to identify Ontario *Panicum* with a key designed for the United States is obviously very helpful.

With the reservations noted below, Dore and McNeill's *Grasses of Ontario* is sensibly produced. The introductory chapter explaining the layout of the book, the sources used, and directing the reader elsewhere for morphological interpretations necessary for grass identification is sensibly brief. The taxonomic part includes keys to genera, species, and sometimes infraspecific taxa. Distribution maps of most species, line drawings of a few, numerous photographs of spikelets and caryopses as well as anecdotal information about distribution and sometimes identificatory matters, especially where dispute has existed or there are real identification difficulties, are all of great value. As is customary in regional floras, no species descriptions as such are given.

The book will startle many by its novel format, but because it will probably be used in conjunction with other works providing species descriptions and mod-

ern tribal affiliations, this shortcoming is not great. Nevertheless it is surprising that the authors have not used modern tribal affiliations, and the implication in their introduction that this might cause difficulties is not well founded. Minor typographical errors are quite numerous but will not confuse the careful reader. The maps, particularly, are models of clarity and will be very useful. Somewhat surprising is the virtually equivalent treatment given to essentially transient taxa (e.g. *Pennisetum*) and extremely rare introductions (e.g. *Nardus*) with treatments of common taxa, but perhaps all have equal reason for being properly identified. If space is no limitation then nothing is really lost.

Thus it is essentially at the local level, i.e., critical species distinctions, good keys, and excellent maps, that Dore and McNeill will be invaluable. The book fails to be, but is not intended to be, a handbook of Gramineae taxonomy. Dore's lifework finally sees the light of day, and his great firsthand knowledge of Ontario grasses is at last presented for all to see. One admires the depth of knowledge indicated. McNeill's organizational and taxonomic skills, one assumes, have seen the work into print. He too is to be congratulated with the first author.

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ENVIRONMENT

The Natural Selection of Populations and Communities

By David Sloan Wilson. 1980. Benjamin/Cummings (Canadian distributor Addison-Wesley, Don Mills, Ontario). xv + 186 pp., illus. U.S. $12.95.

At last there is a book in which the theory of group selection has been given the attention it has deserved for over a decade. Someone has finally provided a text with a plausible mechanism for the operation of group selection in nature without using the inconsistent altruistic pathway. In fact, Wilson's models would be nullified if strong altruism were prevalent in nature. Therefore, past arguments rejecting group selection via rejection of the altruistic pathway cannot be used against his thesis.

Wilson stresses models without using conventional constant fitness values. He feels that fitness is spatially and temporally heterogeneous and therefore constant homogeneous population fitness values cannot be used to model natural selection. In short, he feels that individual selection's predictions about relative fitness are artifacts of the homogeneity assumption. Wilson shows the reader that his feelings are indeed plausible with convincing ridicule of conventional population genetics theory. If there is spatial and temporal genetic variation in a population, as we strongly suspect, Wilson's models most likely are true. He shows that the differential productivity of groups (group selection) is an inevitable consequence of relaxing the homogeneity assumption. Conventional models of homogeneity only fit when applied to tiny populations.

Wilson believes that demes in nature are made up of somewhat philopatric small groups of individuals who ecologically interact more often with their immediate neighbors and microclimatic conditions and therefore are likely to experience similar selective pressures regardless of genetic relationships. Because of these similar selective pressures, these small groups are to some extent similarly genetically structured and are termed *trait groups*. Wilson terms demes of this type *structured demes*. A population of a species is envisioned to be made up of many *structured demes* each subdivided into still smaller *trait groups*. It is the genetic variation within and between trait groups on which Wilson is concerned. The increase of genetic variation among trait groups is always associated with the regulation of population density at optimum size.

Selfish behavior of individuals causes the differential fitness of populations and communities through what is termed *indirect effects*. For example, bark beetles create galleries under tree bark while feeding. This creates a habitat for many insects that can inhabit trees only where beetles are present. The theory of structured demes predicts that bark beetle predators come from "outside" the community the bark beetle creates. The data support this theory. Wilson shows that conventional coevolutionary theory cannot account for this observation and indeed predicts the opposite trend (cf. p. 119–126). Interesting analogies of *indirect effects* in human communities are provided.

According to the theories presented here, it becomes altruistic to compete with (or exclude) another individual from gaining resources when the population size is below optimum. After all, if an animal wastes time competing instead of reproducing when resources are abundant, he is reducing his potential fitness. Dominant individuals chase lowly

subordinates from their area while the rest of the deme (intermediates) enjoy reduced interference, improved conditions, and possibly increased productivity without sharing the costs. In this case, Wilson points out that lowly subordinates are selected against, but dominance is neutral at best. The entire deme is rid of subordinates which is a group advantage. Regardless of the underlying causes of this event, the group has benefitted through the *indirect effects* provided by the direct beneficial effect the dominant individual was trying to obtain. In short, a large portion of an individual's fitness is indirectly influenced by the activities of other members in the community, and these influences are not accounted for in conventional models.

Throughout the text, mathematical models reinforce the verbal arguments, but are not used to make them. Models show how a lower fecundity is favored by selection in one generation. Examples show where niche differentiation between stages (e.g., larva vs. adult insects) cannot be explained by individual selection (cf. p. 57–64). Models show that in some cases individual fitness is maximized only if the individual performs in the best interests of the community. Models for multilevel evolution in the final chapter (6) provide ample mathematical evidence supporting all contentions presented throughout the text. In short, these show that structured deme theory causes increased community productivity until an equilibrium at an adaptive peak is reached.

Perhaps some will criticize that Wilson is repetitious in stating his theories. I feel, however, that he keeps reminding the reader of them because his ideas are so novel that one will forget their components unless reminded. Also, a few passages are difficult to grasp while conventional evolutionary theory is engrained in the reader's mind because of his earlier training. Repetition of these passages makes one understand the significant contribution to evolutionary science that Wilson makes. Overall, most discussions are written in a way that allows the careful reader to understand Wilson's theories as though they were common sense.

No serious naturalist should proceed into the future without reading this book, perhaps the most significant work of natural selection advanced within 15 years. Skeptics need only read pages 13–20; if they are still entirely skeptical, they needn't read further.

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Circulation Models of Lakes and Inland Seas

By T. J. Simons. 1980. Canadian Bulletin of Fisheries and Aquatic Sciences, Bulletin 203. Supply and Services Canada, Hull, Quebec. 146 pp., illus. $12.00 in Canada; $14.40 elsewhere.

As Simons points out in his introduction, there has been increasing activity in the field of modeling both because of demands from many disciplines needing information on water movement and as a result of the increasing capabilities of modern computers. This book comes conveniently at a time when some of the basic modeling methods involving depth averaged currents and transports are sorting themselves out into standard procedures, and more complex models with vertical variation of current and density are proliferating. Thus the book is a valuable summary of models to date and an indication of present trends and limitations.

The title suggests a restriction to circulation in enclosed small bodies of water, and in fact the open-boundary problem and tides are not considered. In addition the modeled area is taken to be small compared to the weather systems that influence it. There is still, however, a considerable amount of material applicable to ocean modeling. There is some examination of surface response since it can be a useful tool in circulation model verification and in theoretical examinations. There are many examples for ocean modeling and many analogies and references to the atmospheric sciences from which ocean and lake modeling traces much of its development.

The book gives a good background. Terms such as Rossby waves and Ekman number are developed and defined in context, instead of just being dropped. Illustrations are used to good advantage often in the context of theoretical models of simple geometry leading to more complex models of real lakes and basins. Simons uses many examples, frequently from his own extensive work, and supplements these with a wealth of references. Most of the book deals with the analytical bases of the models, with only one chapter devoted to numerical procedures. If the book only had an index and possibly a symbol table, it would be an ideal reference book.

In his preface Simons says he is aiming the book for "investigators of water quality problems and other ecological concerns." For these people it is a very useful book, provided they already have a good foundation in university level mathematics and perhaps some ideas on fluid mechanics. A field naturalist without this background trying to evaluate what this

technical field has to offer his science would have difficulty extracting that information. In any case, the low cost of this book makes it a bargain compared to most of the modern literature available.

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Avian community structure of six forest stands in La Mauricie National Park, Quebec. 1980. By J.-L. DesGranges. Canadian Wildlife Service Occasional Paper, 41. Environment Canada, Ottawa. 34 pp., illus. Free.

The biology and physiology of the living coelacanth. 1979. Edited by John E. McCosker and Michael D. Lagios. Papers from a symposium, June, 1977. California Academy of Sciences, San Francisco. vi + 176 pp., illus. U.S. $10.

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***Birds of prey of the world.** 1980. By Friedhelm Weick, in collaboration with Leslie H. Brown. Parey (U.S. distributor IR Unlimited, New York). 159 pp., illus. U.S. $48.

***Birds of Regina.** 1980. By Margaret Belcher. Revised edition. Special Publication Number 12. Saskatchewan Natural History Society, Regina. 151 pp., illus. $5 plus 50¢ postage.

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The fishes of the islands in the South China Sea. 1979. By the South China Sea Fisheries Institute and Others. Science Press, Beijing, China. 613 pp., illus. No price given.

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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 95, Number 3

July-September 1981

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Cover: Deer Mouse, *Peromyscus maniculatus*, photographed in mixed forest near Burritts Rapids, Ontario, on 13 August 1971 by Donald A. Smith. See Article on page 319.

The Canadian Field-Naturalist

Volume 95, Number 3 July-September 1981

Editorship of *The Canadian Field-Naturalist*

It is with regret that The Ottawa Field-Naturalists' Club announces the decision of Dr. Lorraine C. Smith not to accept reappointment as Editor of *The Canadian Field-Naturalist*. Dr. Smith has edited the journal efficiently, effectively, and with great dedication for nine years, a period almost double that of her recent predecessors. In two decades *The Canadian Field-Naturalist* has grown extensively in both size (200 pages annually in 1960 to 500 pages annually now) and stature. The former is largely dependent upon our authors; the latter is due in no small measure to Lorraine. During her tenure she successfully guided *The Canadian Field-Naturalist* to its present role as an important medium for recording the results of research and field observations in natural history. With a full-time professional appointment of her own, Lorraine's work as Editor had to be pursued in her "spare time," of which in consequence she had little to devote to other interests. The Ottawa Field-Naturalists' Club and, we are sure, all readers of *The Canadian Field-Naturalist* thank Lorraine sincerely for her long and devoted service as Editor and wish her success and fulfillment in her future endeavors.

ROGER TAYLOR
President, The Ottawa Field-Naturalists' Club
R. E. BEDFORD
Chairman, Publications Committee

Editor's Thanks

As Editor of *The Canadian Field-Naturalist,* I had the great fortune and pleasure of 'meeting' many interesting and nice people. Moreover, the rapport that developed between many authors and referees and me was welcome and very gratifying. I have enjoyed particularly happy relationships with the Associate Editors and I sincerely appreciate the fine job they have done in evaluating the scientific worth of manuscripts. During my editorship I received much valued expert advice from Earl Godfrey, Pete Peterson, Bob Wrigley, Stan Rowe, Herb Lawler, Ernie Brodo, Tony Keith, and Bob Risebrough (all retired); Ed Bousfield and Dave Scott (retiring with me); and Charley Bird, Francis Cook, Tony Erskine, Charles Jonkel, Charley Krebs, George La Roi, Bill Pruitt, and Steve Smith (all continuing to serve the journal). My sincere thanks to them all for helping me maintain the scientific quality of the journal.

I also put on record here my heartfelt thanks to all those other persons who have helped me with the journal but have received little formal recognition for their contributions. Marilyn Dadswell, the journal's first Copy Editor, served for almost eight years (1973–1980) and did a fine job in helping upgrade its technical quality. Patricia Lalla kindly agreed to carry on as Copy Editor during the remainder of my editorship. When Joe Dafoe offered to lend a much needed helping hand in 1975, I appointed him the journal's first Production Manager. Late the following year Joe left for Australia, so I asked Pauline Smith (no relation) to carry on this important work. She will now be leaving the journal after conscientiously seeing five years of issues into print: I have always been deeply appreciative of her devoted and competent service.

Diligent and careful work on the useful annual indices during my editorship was completed by Stan Teeple, Emerson Whiting, and Harvey Beck. The book review section, under Iola Price, Anne Dagg, and since July 1975 under the enthusiastic and dependable Wilson Eedy, has become an important component of the journal. I am grateful too to Business Manager Bill Cody who has contributed significantly not only to his particular parts of the operation but to other aspects as well, and to Emil Holst who has served as our very affable contact at M.O.M. Printing.

And finally I give my very special thanks to my husband Don who as Assistant to the Editor has given me continuing support through his advice and help in scientific, editorial, cartographic, and clerical matters and also total backing in controversial and emotional issues.

I am indeed indebted to my many associates for what they have done and I thank them all for their help, time, and for the pleasure and knowledge I have gained in being associated with them.

LORRAINE C. SMITH
Editor (1972-1981)

Editor's Farewell Musings

For historical and general interest reasons, I decided to document what the editorship of *The Canadian Field-Naturalist* has entailed for me, the changes initiated, major decisions made, actions taken, and what I consider my important accomplishments.[1]

Normally a scientific editor's role is to evaluate, with the help of referees who are chosen because they are specialists in certain fields of study, the scientific content of submitted manuscripts and to accept for publication material that significantly advances scientific knowledge within the scope of the journal. Most editors take special pride in the results of their endeavors and I certainly feel that the issues of *The Canadian Field-Naturalist* produced under my editorship have been of high quality. Moreover, as the person responsible for the content of the journal, I tried to ensure not only that papers conformed to certain standards (i.e., that they met the criteria for acceptance) but that their presentation was as understandable as possible to the average reader.

The attention an editor gives to each submitted paper differs from journal to journal and from editor to editor of the same journal. Some editors rely completely on the chosen referees (and advice if needed from members of their editorial boards) and hence never actually read the submitted papers. Because scientific editors are sometimes appointed for only short time spans and must carry on as well the work associated with their regular permanent positions, many don't take extra time with each paper. Although *The Canadian Field-Naturalist* is a general journal and no one person can be knowledgeable in all the areas it covers, I have always read each submitted paper whatever the subject. It is usually possible to evaluate generally the research or observations upon which a paper is based, to discern whether the contribution is placed in the proper perspective concerning the state of knowledge of the subject, to determine if it is clear and concise, and if its organization is logical and geared to the stated purpose. Moreover, I think that to control the quality of the accepted papers, an editor should try to ascertain that the results are valid, accurate, and important, and that the language and presentation are comprehensible. Although to me the quality of writing is important, others have argued that if the new information is communicated to readers, other 'improvements' are unnecessary. Nevertheless I believe the final published products have been better because of my editorial assistance to authors. It is obvious to many of them too that I cared.

When I somewhat reluctantly agreed to take on the editorship of *The Canadian Field-Naturalist* in 1972, in addition to the scientific editing and processing of manuscripts, I assumed other unexpected responsibilities. I was also the office staff (filing, keeping records, and typing), production staff (preparing a mockup of the journal, correcting proofs, and seeing the operation through to the final production stage), and copy editor (marking manuscripts for the printer; correcting the spelling, punctuation, grammar, and English and French composition; and reading the galley proofs). Unfortunately, there has been a decline in general competence in writing in the English and French languages and authors who lack good communications skills benefit particularly from the skills and experience of editors and copy editors. Some of my first chores as Editor also included starting a much-needed referee file and preparing standard letters, cards, and other forms for routine correspondence.

Because there were so many extra duties to perform, the position was a great deal more time-consuming than I had imagined. Moreover, the location and maintenance of the editorial office in our private home put considerable constraints on obtaining clerical, typing, and other assistance. Unfortunately, because it has been difficult for others to imagine the extent of the enormous work load, it has also been difficult to obtain help, needed support, or approval for funds to pay assistants. Eventually the publisher approved a token remuneration for a Copy Editor and I was able to obtain the services of an experienced person in 1973. By 1975, I had arranged for a volunteer Production Manager. Even so, the time I continued to expend editing *The Canadian Field-Naturalist* has been so extensive (more than 800 hours per year) that I have had to forgo most other activities.

Throughout my editorship, I have strived to improve the format and style of the journal; some of these innovations are recorded in my annual published "Editor's Reports." In 1977 I published an editorial detailing current editorial policy. A new series entitled "The Biological Flora of Canada" was launched in 1979 and a new method of reporting some range extensions under the heading "Reports of Significant Range Extensions" was started in 1980. Several manuscripts for these sections are in process and others continue to be submitted; I expect the series will soon be well-established components of the journal. In late 1973 I submitted the first

[1]Additional detailed notes are on file with The Ottawa Field-Naturalists' Club.

material supplementary to one of our published journal papers to the Depository of Unpublished Data (located at Canada Institute for Scientific and Technical Information, National Research Council of Canada, Ottawa). Other relevant material has been deposited there from time to time and is always available to any interested person requesting it.

The Canadian Field-Naturalist was at last selected for inclusion in *Current Contents/Agriculture, Biology, and Environmental Sciences* starting in 1977, and it was included as a "source publication" in the Science Citation Index starting in 1979. These last two actions signify formal acceptance of *The Canadian Field-Naturalist* as a primary scientific journal by the North American scientific community.

Although well established and now widely recognized as a scientific journal, *The Canadian Field-Naturalist* is in the rather anomalous position of being published, not by a scientific society, but by The Ottawa Field-Naturalists' Club, a local natural history club. In the past many professional biologists have served on the club's Council but hardly any do so anymore. This change has serious implications for *The Canadian Field-Naturalist* in the long run because the Council appoints (and can dismiss) editors and otherwise can have considerable influence on the journal. For example, the Ad Hoc Committee on Club Publications, approved in principle by the Council in November 1978 as a result of unspecific rumors of "unease" within the club about *The Canadian Field-Naturalist*, and set up in November 1979, had a narrow and restricted data base for its deliberations because opinions of editors, managers, subscribers, readers, and authors were not solicited. This committee presented its report to Council in November 1980. Eventually its recommendations, perhaps in a modified form, will be approved by the Council as club policy. Some of the recommendations are blatantly contrary to current editorial policy and practices, some are real infringements on editorial freedom, some cast doubt on the capabilities of some Associate Editors (based it seems on mistaken hearsay evidence), and others have the appearance of being new when, in fact, they represent the *status quo*. And yet the club's policy on this journal (and other publications) will be decided by a Council most of whose members and executive have little knowledge, understanding, or appreciation of what primary biological publication is all about. Will this be acceptable to those the journal now serves?

Because of my reluctance to continue the tremendous work load I have carried in my "spare time" for nine years of journal issues and because of what I have perceived as the lack of trust, appreciation, and support by the club, I informed the Council that took office in January (I had already alerted the Publications Committee Chairman in mid-1980 about this possibility) that my term of office was completed and I would decline a reappointment. I did, however, agree to put out the present issue; this will thus be the last appearing under my editorship. I wish readers to know, however, that it was with considerable regret that I took this action not only because the journal has become an important part of my life but also because feedback from the scientific community has assured me that the high quality and standards I instituted and my personal attention to improving manuscripts have been deeply appreciated.

Through expenditure of considerable time and effort during my term of office, I have applied my knowledge and ability to upgrade the scientific and technical quality of *The Canadian Field-Naturalist*. One of my first and probably the most important of my major policy changes was to adopt a consistent and rigorous peer review system by commencing to send each submitted manuscript to *at least two* referees. Previous editors had either not done this or had done so only occasionally; most manuscripts submitted to them were accepted either after evaluation by only an Associate Editor or surprisingly often with no external review at all. Another important policy change was to limit the contents of the journal to information that is original (i.e., confirmatory material although of importance to have on record was directed elsewhere), scientifically sound, and of importance at the national level. Moreover, I have always helped authors to convey their messages including interpretations of their observations as clearly, concisely, and intelligibly as possible.

It is particularly important to me that my successors should try to maintain the scientific and technical quality I have built up. Of course, the cornerstones of a successful primary scientific journal are a good editor and a functional peer review system. That is why I strongly recommended that the new editor should be an experienced and competent biologist (preferably with a Ph.D.) who is highly respected by other scientists and who is responsible, well organized, efficient, dependable, dedicated to the reporting of good science, dedicated to the expenditure of considerable time for the sake of communicating good science via the journal, tactful, diplomatic, and perhaps what is most important of all, able to exercise sound judgment. This latter quality is especially needed to determine if there is new knowledge worth reporting and if its presentation meets high scientific and technical standards. Of course, an editor should have good communication skills to maintain credibility. Also, for a generalist journal, an editor should have broad interests and be widely experienced in science especially for choosing the right referees. Nevertheless, I was informed recently by two members of the

current Search Committee (neither I as retiring Editor nor any other scientist with specialized training in biology were asked to serve on this committee) that because of expediency almost the sole criteria for the choosing of a new Editor became availability, willingness to serve, release time by the employer to carry out editorial duties during office hours, and the promise of secretarial help from the employer. Surely if new editors are to be chosen on a hit-or-miss basis by laymen-naturalists using or emphasizing such criteria, however important they may be, rather than those listed earlier, the journal could sooner or later run into serious problems of quality and credibility.

Although there has been a long association of The Ottawa Field-Naturalists' Club and *The Canadian Field-Naturalist*, I strongly urge that concerned readers and authors consider the possibility of an alternative publisher, a science-based one that will vigorously support a journal reporting observations and results of investigations in all fields of natural history provided that they are original, significant, and relevant to Canada. Of course such a hypothetical new publisher should be financially sound and otherwise stable as well. Perhaps, too, another publisher would give more support to the Editor in delegating to him or her the responsibility for the journal. At least the time-consuming local club politics and misdirected unjust criticisms, which presumably resulted from the restricted interests and lack of knowledge by many members of the club's Council regarding primary publication of biological information and which necessitated large unproductive portions of our valuable time to be taken up with defensive actions, might no longer exist. Of course, the club has gained in stature from its role as publisher of this journal and its predecessors (since 1880) and it may not wish to relinquish control. Nevertheless, the burden of being accountable to the scientific natural history community for a national journal and especially the serious responsibility of choosing new editors may now be more that this local club should retain. Therefore, in the future if the journal's reputation is not maintained, and there is no move for a change in publisher, I challenge those who want a top-quality Canadian natural history journal, such as *The Canadian Field-Naturalist* is now, to initiate a new journal.

Because I have dedicated myself to its scientific and technical editing for so long and because I have a vested interest in the future of *The Canadian Field-Naturalist*, I sincerely hope that this journal or its replacement will continue to fill an important role communicating information of scientific worth in natural history and that it will do so in a readily comprehensible and retrievable manner. Moreover, I hope that rational procedures can be instituted to ensure that the current scope, quality, and standards of the journal, and its consequent support by authors and recognition by the scientific community will be maintained.

There is no doubt that I will miss the journal and the enjoyable contacts I have had with authors, referees, Associate Editors, and my other coworkers on *The Canadian Field-Naturalist*. Many thanks to those who have helped and supported me during my editorship.

LORRAINE C. SMITH
Editor (1972–1981)

Is the Impact Factor a Meaningful Index for the Ranking of Scientific Research Journals?

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Taylor, Roger. 1981. Is the Impact Factor a meaningful index for the ranking of scientific research journals? Canadian Field-Naturalist 95(3): 236–240.

In a given year the Impact Factor for a journal is defined as the number of citations to papers published in the previous two years in that journal divided by the total number of these papers. This is often used as a measure of a journal's effectiveness. I have shown that, as defined, the Impact Factor can give a distorted view of the worth of some journals. In particular, field-biology journals such as *The Canadian Field-Naturalist* seem to be badly misrepresented by this index. I propose an alternative definition of the Impact Factor which is a more realistic measure of the importance of a journal to the scientific community. The two corrections that I suggest take account of the fact that (a) some disciplines, notably field biology, take a much longer time from conception to completion of a project and (b) the average length of a paper varies considerably from journal to journal.

Key words: Impact Factor, citation, field-biology, journal ranking.

The *Scientific Citation Index,* published annually since 1963 by the Institute for Scientific Information in Philadelphia, has become over the intervening years a widely used tool for evaluating the usefulness of published papers to the scientific community. It analyses all citations contained within papers published in a set of "source journals" (currently about 3000) and groups them in various ways. Perhaps the best-known and most commonly utilized grouping is by author of cited articles. Despite some very obvious criticisms, the ranking of scientists by number of citations is clearly more meaningful than ranking by number of articles published, and this procedure is becoming widely accepted. Hence it should come as no surprise that similar ranking procedures are becoming adopted for journals. Starting with 1975 the Institute for Scientific Information has included in the *Science Citation Index* a volume entitled *Journal Citation Reports* (Garfield 1976a) which contains analyses of scientific journals and their impact on the scientific community. Among other things, the data contained in this publication make it possible to rank scientific journals in two ways. One is by the total number of citations received and the other is by Impact Factor. The Impact Factor is basically a ratio between citations and citable items published. It is computed for any particular journal for the year 1979, say, in the following way. The total number of citations, in all journals in 1979, of 1977 and 1978 papers published in the particular journal '*X*' is divided by the total number of these same 1977 and 1978 papers to give the Impact Factor. For example, if *X* published 100 articles in 1977 and 1978 and if in 1979 these articles were cited 48 times, the 1979 Impact Factor for *X* would be 0.48. There are many other possible choices of Impact Factor and some of these are discussed by Garfield (1972), but this index clearly provides a more meaningful basis for journal comparison than a simple listing of numbers of journal citations. To put things in perspective, an Impact Factor of 1.00 is considered to be good.

In discussing relative assessments of scientific journals Garfield (1972, 1976a, b) emphasizes that caution should be used and that statistics should not be taken out of context. The very nature of a journal can appreciably affect its citation frequency (e.g., compare *Scientific American* with *Journal of Molecular Biology*) and different fields are not always comparable. Nevertheless the Impact Factor is an easily accessible ranking parameter, and there is a temptation to use it without due consideration of circumstances. Recognizing this fact it is clearly desirable to construct an Impact Factor which takes into account, in some way, fundamental differences between the journals that are being studied. This is particularly important when making comparisons such as those in *The Press of Knowledge* (Royal Society of Canada 1978).

The purpose of this article is to point out that, as presently defined by the *Science Citation Index*, the Impact Factor badly misrepresents some areas of science such as field biology and to suggest an alternative definition that seems to allow for a much more meaningful comparison of journals from different fields. This is particularly important for journals such as *The Canadian Field-Naturalist*.

The Press of Knowledge, commissioned by the National Research Council of Canada and prepared by the Royal Society of Canada, is the report of a committee that undertook a study of policies and practices for publication of research journals in Can-

ada. The committee noted that there were 67 primary scientific, medical, and engineering journals published in Canada and that 38 of them were included among the 2630 source journals analyzed in the 1975 issue of *Journal Citation Reports* (Garfield 1976a). In Table II of *The Press of Knowledge* these 38 journals are ranked according to total number of citations in 1974 and to 1974 Impact Factors. The latter ranges from a high of 1.671 for the *Canadian Journal of Biochemistry* to a low of 0.051 for the *Canadian Aeronautical Space Journal.* By implication those other 29 Canadian journals that are not included in this list (e.g., *The Canadian Field-Naturalist*) should be considered to have impact factors even lower than 0.051. In fact, there is no further mention of any of the 29 non-source journals in *The Press of Knowledge* and it is hard not to draw that inference of inferior quality, even if it was not intended by the authors of the report. This is simply one example of a situation where journals from vastly different fields have been compared using Impact Factor, and the points I will make in the following paragraphs are first that the currently defined Impact Factor is a poor basis for such a comparison and second that if such comparisons must be made, a much better index can be used.

If we focus our attention on *The Canadian Field-Naturalist,* we find that we have to turn to the year 1978 to obtain an Impact Factor because it does not appear to be reported in earlier years. In the journal-ranking package of the 1978 issue of *Journal Citation Reports* (Garfield 1979), the value 0.127 is given for this quantity, marginally better than 0.051 but certainly not an impressive figure. However, we must keep in mind that because *The Canadian Field-Naturalist* is not a source journal, this figure does not contain self-citations, so that it is clearly low. To generate the 1978 Impact Factor the total number of citations of papers published in 1976 and 1977 should be divided by the total number of papers (referred to as source items) published in the same two years, but for some unexplained reason only the last two issues of 1976 were included in the figures. This again is a misrepresentation since 1976 articles are more likely to be cited in 1978 than are 1977 articles. Therefore all four 1976 issues should have been included. To correct these deficiencies in the published Impact Factor, I have determined the number of self-citations in 1978 of 1976 and 1977 papers and doubled the number of citations for 1976 articles. The results are summarized in Table 1 which shows that the corrected Impact Factor, hereafter referred to as I_0, is equal to $44/209 = 0.211$. I shall take this to be the Impact Factor as generated by the *Science Citation Index* prescription.

Now if we look carefully at *The Canadian Field-Naturalist*, it readily becomes apparent that there are two factors which work to produce a low Impact Factor. The first of these is the unusually high number of notes making up the content of the journal. Of the 110 Source Items in volume 90 (1976 year) of the journal, only 41 are full-length articles and 69 are notes. The articles cover 310 pages whereas the notes cover only 131 pages. The average article in that volume, therefore, is about seven and a half pages long and the average note only about two pages. This ratio of articles to notes is certainly not typical of a scientific journal. Generally speaking, within a given journal, the probability of an article or note being cited will be roughly proportional to its length. Of course some short papers can have major impact and be cited heavily whilst other verbose papers on obscure topics can be entirely ignored, but, on average, if a journal is carefully edited, a long paper will contain more citable information and refer to a broader field than a short one. Therefore, each individual note will draw fewer citations than an article although it is reasonable to assume that any group of four notes is likely to draw about the same number of citations as an article. Hence the presence of an unusually large number of notes in *The Canadian Field-Naturalist* will result in a disproportionately small Impact Factor because each note is treated as a source item despite the lower citation probability, which has nothing to do with scientific content.

TABLE 1—Number of citations in 1978 to papers published in *The Canadian Field-Naturalist*

Year	Citations			Source items[a]
	Self	Other	Total	
1976	7	30[b]	37	110
1977	3	4	7	99
1976–77	10	34	44	209

[a]The total number of scientific papers (excluding editorials, book reviews, news and comment etc.) published by *The Canadian Field-Naturalist* in the indicated year(s).
[b]Because the number of citations for 1976 in the 1978 *Science Citation Index* includes only two issues, this number has been doubled to represent the entire year.

The second factor working to the detriment of *The Canadian Field-Naturalist* Impact Factor is the very nature of the research that is published therein. It is exclusively field biology which frequently requires a much longer time between conception and completion of a project than does laboratory work. In referring to a chronological distribution of cited papers Garfield (1972) stated, "An analysis of this distribution has shown that the typical cited article is most heavily cited during the 2 years after its year of publication." One has only to peruse the citation pages of any issue

of *The Canadian Field-Naturalist* to appreciate that this is certainly not true for that journal and it is obviously because of the nature of the research. Garfield's comment clearly refers to laboratory work. To confirm this difference between laboratory and field work, I plotted histograms of the chronological distribution of citations occurring in the 1978 issues of *The Canadian Field-Naturalist* and of the February, May, August, and November 1978 issues of the *Canadian Journal of Physics*. These are shown in Figure 1 (A and B). Consistent with Garfield's comment, the *Canadian Journal of Physics* distribution of citations shows that the peak years are 1976 and 1977 whereas for *The Canadian Field-Naturalist* they are 1973 and 1974. As a test of my hypothesis, I also plotted a histogram of the corresponding distribution for the February, July, and November 1978 issues of the *Canadian Journal of Zoology* which contains a mix of laboratory and field work (Figure 1C). There a double-peaked distribution seems to be present, with the peaks centered on 1975–1976 and 1972–1973. This distribution appears to be intermediate between the two foregoing ones and this I confirmed by isolating a subgroup consisting of those papers which reported exclusively field work. This subgroup of the *Canadian Journal of Zoology* papers gave a distribution, peaked in 1973, which was very similar to that of *The Canadian Field-Naturalist* (Figure 1A). The remainder, by the way, consisting of laboratory or laboratory plus field work, gave rise to a distribution quite similar to that of the *Canadian Journal of Physics* but with the peak years in 1976 and 1977 and with an appreciably smaller peak in 1973. Clearly then, to base an Impact Factor for 1978 solely on citations for 1976 and 1977 articles does not do justice to journals with a significant amount of research requiring long periods between conception and completion.

I can suggest two corrections that can be applied to the Impact Factor I_0 to make it more meaningful to compare journals of different disciplines. To correct for the problem caused by unusually large numbers of notes, we could, first of all, define a standard source item as containing, say, 7500 words. Then we could compute the number of standard source items from the number of words per page and the number of pages for the years under consideration. Using the number of standard source items to compute the Impact Factor gives an effective Impact Factor, hereafter referred to as I_1. I estimate the number of words per page for *The Canadian Field-Naturalist* to be 750, the number of pages in 1976–1977 to be 797 (This excludes editorials, book reviews, etc., which are not included in the *Science Citation Index*) and therefore the number of standard source items to be 79.7). Hence $I_1 = 4/79.7 = 0.552$, a much more respectable looking number than I_0. It is interesting to compare I_0

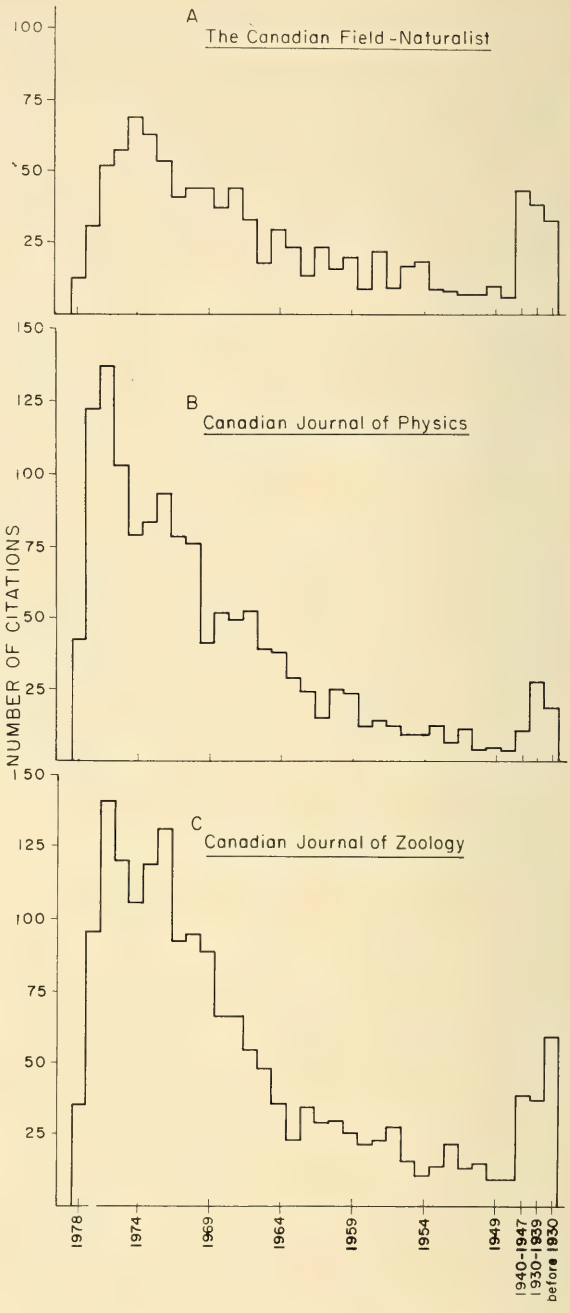

FIGURE 1. The chronological distribution of citations contained in papers published in (A) *The Canadian Field-Naturalist* in 1978 (all four issues), (B) the *Canadian Journal of Physics* in 1978 (February, May, August, and November issues), (C) the *Canadian Journal of Zoology* in 1978 (February, July, and November issues).

and I_1 for 1978 for eight of the Canadian Journals of Research published by the National Research Council of Canada. The results are displayed in Table 2. They are based on an estimated 900 words per page for these journals. As one might expect, in most cases, the change from I_0 to I_1 is not very large because the numbers of notes are relatively small. The most noteworthy change, relatively speaking, is for the *Canadian Journal of Earth Sciences* where $I_0 = 0.980$ and $I_1 = 0.697$. Apparently earth scientists write longer articles than do those in other disciplines.

TABLE 2—1978 Impact Factors for eight of the Canadian Journals of Research. I_0 is computed using the SCI definition and I_1 is computed using the number of standard source items (see text).

Journal	I_0	I_1
Canadian Journal of Physics	0.982	0.971
Canadian Journal of Chemistry	1.516	1.765
Canadian Journal of Earth Sciences	0.980	0.697
Canadian Journal of Botany	0.986	0.897
Canadian Journal of Zoology	0.879	0.890
Canadian Journal of Physiology and Pharmacology	1.308	1.469
Canadian Journal of Biochemistry	1.543	1.874
Canadian Journal of Microbiology	1.073	1.296

To correct for the problem of the different chronological distributions I suggest that for each journal the percentage of all citations occurring for 1976–1977 be computed and used as a basis for renormalizing the 1978 Impact Factor to give a new index called I_2. This can of course be done for any year. For *The Canadian Field-Naturalist* this percentage is 8.6%, for the *Canadian Journal of Zoology* it is 13.5%, and for the *Canadian Journal of Physics* it is 19.4%. If we choose arbitrarily to say that 19.4% is what we would expect for an "average" journal, then we compute I_2 for *The Canadian Field-Naturalist* by multiplying I_1 by 0.194/0.086. The results for I_0, I_1, and I_2 for all three journals are displayed in Table 3 where we see that for *The Canadian Field-Naturalist*, I_2 is a very respectable 1.240, putting this journal roughly on a par with the two Canadian Journals of Research. In other words the two suggested corrections actually increase the Impact Factor for *The Canadian Field-Naturalist* by a factor of 6, and by a factor of about 1.5 for the *Canadian Journal of Zoology* whilst making no change for the *Canadian Journal of Physics*.

TABLE 3—1978 Impact Factors for three journals including a correction for the chronological distribution of citations (I_2)

Journal	I_0	I_1	I_2
Canadian Journal of Physics	0.982	0.971	0.971
Canadian Journal of Zoology	0.879	0.890	1.279
The Canadian Field-Naturalist	0.211	0.552	1.240

Implicit in the correction leading to I_2 is the assumption that the chronological distribution of citations for articles published in journal X will be about the same as the distribution of citations within the same journal. This is not an unreasonable assumption because both distributions reflect activity within virtually the same field of scientific research. Any further corrections to take into account the small differences between the two distributions would be much more complicated and would be unlikely to produce significant alterations to I_2.

The foregoing arguments are not a thinly disguised attempt to make *The Canadian Field-Naturalist* look good. They should be regarded as some suggestions for correcting what is clearly a poor procedure for comparing journals of different disciplines. The example of *The Canadian Field-Naturalist* shows how poor this can be. The chief proponent of the Impact Factor concept, Garfield, would not recommend making such comparisons, judging by many of his remarks (Garfield 1972, 1976b). Nevertheless, as long as the data are there, these comparisons will be made. Although, in the report of the Royal Society of Canada (1978), the committee warns against using the Impact Factor as the sole basis of judgment, the very fact that they rank the journals in this way in tabular form and dismiss those journals for which no data were available make it all too easy for others to come to poorly conceived conclusions. By using the renormalized effective Impact Factor I_2, the data can be presented in a much more equitable fashion.

As a final comment, a glance at the journal-ranking package contained in *Journal Citation Reports* (Garfield 1979) reveals that the top-rated journals are of a review nature with Impact Factors greater than 20. If the above procedures were used, these Impact Factors would be cut down to a size which would more truly reflect their importance to science. I very much doubt that any scientist when asked to name the three most important journals for his research would include a review journal in the list.

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Received 1 December 1980
Accepted 7 March 1981

Vegetation with Atlantic Coastal Plain Affinities in Axe Lake, near Georgian Bay, Ontario

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Keddy, P. A. 1981. Vegetation with Atlantic coastal plain affinities in Axe Lake, near Georgian Bay, Ontario. Canadian Field-Naturalist 95(3): 241–248.

Axe Lake is a small, sandy lake about 25 km NW of Huntsville, Muskoka District, Ontario. Many species with eastern or Atlantic coastal plain affinities occur in the lake, including *Muhlenbergia uniflora* (One-flowered Dropseed), *Juncus militaris* (Bayonet Rush), *Nymphoides cordata* (Floating-heart), *Rhexia virginica* (Meadow-beauty), *Rhynchospora capitellata* (beak-rush), *Woodwardia virginica* (Virginian Chain-fern), *Utricularia purpurea* (Purple Bladderwort), and *Xyris caroliniana* (Yellow-eyed Grass). The lake occurs on the edge of a sand plain which marks the former high waterline of postglacial Lake Algonquin. The vegetation of this lake may thus be of a relict shoreline type which was formerly much more widespread in the sandy bays of postglacial Lake Algonquin. Extensive beds of emergents and shallow water aquatics occur on the gently sloping shores. During July 1979, quantitative data on species composition were collected, using 25 transects run from 0.5 m above to 0.5 m below the waterline. These transects represented much of the variation in species composition and substrate types occurring in Axe Lake (except for floating bog mats and rock outcrops). The transects were divided into three categories based on the substrate type of the shoreline at 0.5 m above the waterline: sand (mean = 0.9% organic matter), transition (mean = 3.7% organic matter), and peat (mean = 16.4% organic matter). Species composition varied markedly among these categories. Many coastal plain species (such as *R. virginica, X. caroliniana,* and *M. uniflora*) reached their maximum abundance in the transition areas. Few occurred in *Sphagnum* bogs elsewhere on the lakeshore. Axe Lake appears to be a small remnant of a larger open water area, most of which is now *Sphagnum* bog. Thus, it appears that bog formation is gradually eliminating a relict type of shoreline vegetation.

Key Words: aquatic plants, coastal plain flora, Georgian Bay, Lake Algonquin, phytogeography, rare species, shoreline vegetation, substrate type.

It has long been known that areas about the Great Lakes, particularly the southern end of Lake Michigan and the sand barrens of northwestern Wisconsin, have floristic affinities with the Atlantic coastal plain of the eastern United States (Peattie 1922; McLaughlin 1932). The Atlantic coastal plain is a relatively flat marginal area of eastern North America which extends as a narrow band up the eastern coast between the Applachian Mountains and the Atlantic Ocean; it ranges in width from a few kilometres on Cape Cod to up to 250 km in Georgia. It is often poorly drained, with extensive wetlands; as well, acid soils are frequent (Fernald 1942). Fernald (1942) was critical of the use of the term "Atlantic coastal plain species" to describe many of the Great Lakes disjuncts, noting that the term was overused, and that "the true members of the Atlantic coastal plain flora are rarely found off the coastal plain." Although some of the species listed by Peattie (1922) and McLaughlin (1932) are questionable, there are still many species known to occur along the Atlantic coastal plain, with extensions northwards into eastern Canada, and inland to the Great Lakes. In spite of Fernald's admonition, the use of the term "coastal plain species" empahsizes the geographical affinities of these species, and thus seems useful to retain in its broader sense (e.g., in Roland and Smith 1969; Voss 1972).

In recent years, there has been growing evidence of another concentration of coastal plain species about the Great Lakes, around Georgian Bay in Ontario. Some of the more notable examples include *Rhexia virginica* (Meadow-beauty) (Soper 1956), *Potamogeton bicupulatus* (pond weed) (Reznicek and Bobbette 1976), *Bartonia paniculata* (Screw-stem) (Reznicek and Whiting 1976), and *Panicum spretum* (panic-grass) (Catling et al. 1977). Reznicek and Whiting (1976) note that other eastern species such as *Listera australis* (Southern Twayblade), *Juncus militaris* (Bayonet Rush), *Gratiola aurea* (Golden-pert), and *Linum striatum* (Flax) have similar disjunct distributions. R. C. Simpson and H. Simpson (1973. The biology of Balckstone Harbour-Moon Island Provincial Park Reserve, Parry Sound District, Ontario. Resource Inventory Report, Ontario Ministry of Natural Resources, Toronto, 153 pp.) found many shoreline species with eastern affinities including *R. virginica*, *P. bicupulatus*, and *Nymphoides cordata* (Floating-heart) on a portion of the Georgian Bay shoreline in Parry Sound District.

Field work on shoreline vegetation in the Muskoka

and Parry Sound areas has revealed another locality for some of these species. This locality, Axe Lake, is further north than previous reports, and is also inland from Georgian Bay. The purpose of this paper is to describe and discuss the vegetation at this locality with reference to the substrate type of the shoreline and the geological history of the area.

Study Area — Axe Lake

Axe Lake occurs on the boundary between Muskoka and Parry Sound districts, about 25 km NW of Huntsville, Ontario (Figure 1). This region has a growing season of between 180 and 190 d. The frost-free period is between 100 and 120 d, with the last frost occurring around 25 May and the first occurring around 20 September. There are between 160 and 180 d per annum with precipitation, for a total of about 100 cm (Department of Energy, Mines and Resources 1974).

Figure 2 shows Axe Lake and the adjacent wetlands. The lake is about 0.5 × 3 km and has a sand bottom with occasional outcrops of Precambrian granitic rocks. The southern third of the lake is largely surrounded by floating bog mats, although in places a sand bottom is exposed during low water periods. The northern two-thirds has scattered boggy areas, and shorelines dominated by shrubs. In deeper water on the lake side of the shrubs, emergent and floating-leaved aquatics are well developed. Most of the lake is shallow enough to support floating-leaved aquatics, producing extensive beds of *Nymphaea odorata* (Fragrant Water-lily), *Brasenia schreberi* (Water-shield), and *Utricularia purpurea* (Purple Bladderwort). Only one area in the northern portion of the lake is deep enough to be free of floating-leaved aquatics. Small streams draining peat bogs enter at both the north and south end; the lake initially drains eastward into Buck Lake and then Lake Vernon, eventually emptying westward into Georgian Bay via the Moon River.

Although no long term data are available on lake

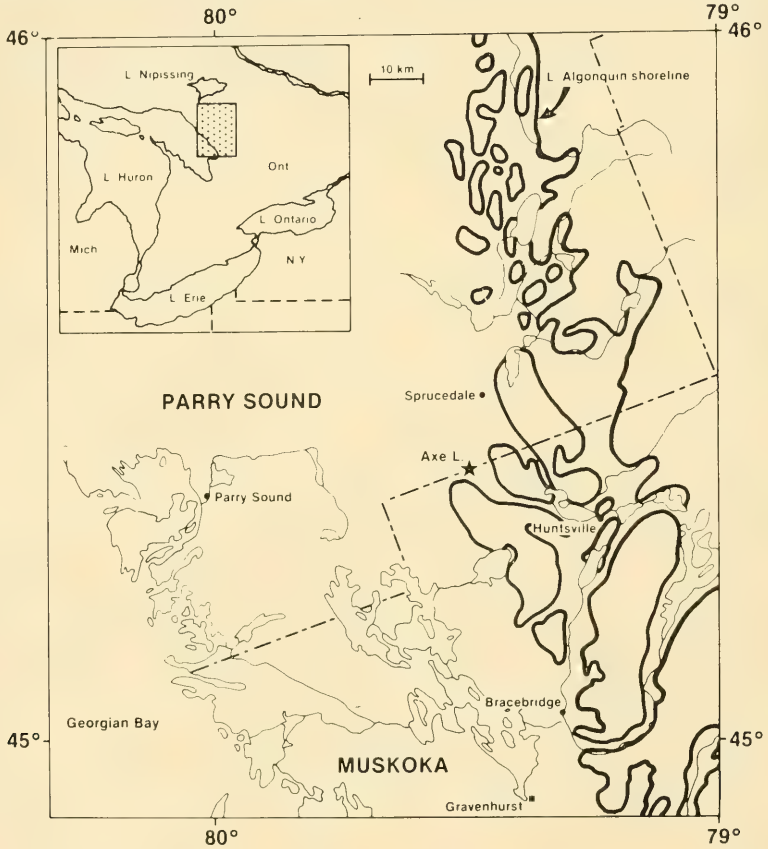

FIGURE 1. Location of Axe Lake relative to existing Georgian Bay shoreline and postglacial Lake Algonquin shoreline. Extensive sand plains parallel the old shoreline (after Chapman 1975, Figure 6).

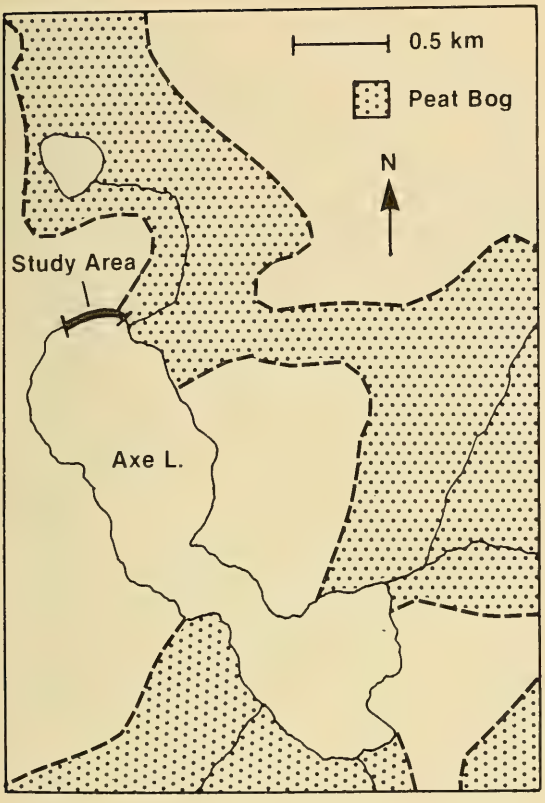

FIGURE 2. Axe Lake and immediate vicinity. Note the extensive areas of peat bog, and the location of the study area.

levels, there is considerable variation. The water level in July 1979 was about 30 cm lower than it had been the preceding autumn. The water level fell another 5 cm from 13 to 21 July. A subsequent visit in September 1979 revealed the water level 20 cm above the July level, approaching that of the previous autumn. While 20- to 30-cm fluctuations may seem minimal, the extremely gentle slopes (as little as 1:250) means that a few centimetres drop may expose more than a metre-wide strip of lake bottom.

Sampling Techniques

Floristic data were gathered over a period of three years: September 1978, July 1979, September 1979, and August 1980. Voucher specimens were taken for most taxa. The problematic taxa (*Potamogeton* and *Carex* in particular) were confirmed or determined by P. W. Ball (Herbarium, Erindale College, University of Toronto) or A. A. Reznicek (Herbarium, University of Michigan). These vouchers are on file in the author's herbarium with duplicates, where available, in TRT, CAN, and the National Water Research Institute Herbarium at the Canada Centre for Inland Waters, Burlington.

The vegetation data were gathered during 13 to 21 July 1979. A 600-m section of shoreline was surveyed along the northeastern end of the lake (Figure 2); this encompassed much of the range of variation seen in the lake as a whole, from open sand beach to mature bog shoreline (but excluding floating bog mats and rock outcrops). Along this perimeter I located 25 transects chosen by means of random numbers subject to the criterion that no two transects could be closer together than 10 m. This ensured that each transect was relatively independent. The transects were sampled in the order that the random numbers were drawn to ensure that variation resulting from changes in observer expertise, working conditions, and/or plant maturity would be randomly assigned along the shoreline.

Each transect contained a belt of vegetation 50 cm wide and was surveyed into 5-cm-height increments using an automatic level. The waterline on 13 July was used as the reference point, and for each transect increments were marked out ranging from 50 cm above to 50 cm below this water level, a total of 20 height increments (or quadrats) per transect. Because the water level fell as the study progressed, daily corrections were made for falling water levels. An observer started at the top of each transect and recorded the presence of each species in each height increment. The final set of data then consisted of lists of species occurrences in 20 height increments for 25 transects.

These randomly chosen transects were assigned to three shoreline types: sand (6 transects), transition (12 transects), and peat (7 transects). For each of these categories frequency of occurrence for each species was calculated by summing all occurrences over all transects and dividing by the total number of height increments examined. For example, 120 height increments (6 transects × 20 height increments) were examined on sand. The proportion of these which contained a given species is a measure of that species' frequency.

Soils data presented are based on samples collected to a 10-cm depth at 0.25 m above the waterline in each transect. Organic content was estimated by percentage loss on ignition at 400°C.

Nomenclature follows Fernald (1950) except for the use of *Triadenum fraseri* (Marsh St. John's Wort), instead of *Hypericum virginicum*. Most common names, where available, generally also follow Fernald (1950).

Results and Discussion

Floristics

Peattie (1922) provided a summary table of coastal plain species known to occur around the Great Lakes. One of Fernald's (1942) main criticisms was that too many botanists thought of the coastal plain flora in ecological rather than phytogeographic terms, thus lumping many species of acid sands and bogs into the coastal plain category. The following discussion of the flora of Axe Lake attempts to separate these components.

Two species from Axe Lake, *R. virignica* and *J. militaris*, are widely disjunct from the Atlantic coastal plain. Their Ontario distribution is largely restricted to the Georgian Bay region, although *J. militaris* occurs north to Temagami District (Fernald 1950) and east to the Ottawa River (M. I. Moore. 1972. Vascular Plants of the Middle Ottawa Valley and Northeastern Algonquin Park. Petawawa Forest Experiment Station Information Report PS-X-34, Environment Canada. 48 pp.). In eastern Canada *R. virginica* reaches southwestern Nova Scotia (Roland and Smith 1969) and *J. militaris* reaches Newfoundland (Fernald 1918).

Other species from Axe Lake are also prominent on the coastal plain and form a strong component of vegetation in the vicinity of coastal plain disjuncts, although there are scattered inland stations elsewhere in North America. Such species include *Eleocharis olivacea* (Olive-brown Spike-rush), *N. cordata*, *Rhynchospora capitellata* (beak-rush), *U. purpurea*, *U. resupinata* (bladderwort), *Woodwardia virginica* (Virginian Chain-Fern), and *Xyris caroliniana* (Yellow-eyed Grass) as well as *J. militaris* and *R. virginica.*

Many more widespread and northern species now occur primarily on glaciated areas off the Atlantic coastal plain, but appear to have survived on the coastal plain during the last glaciation. *Cladium mariscoides* (Twig-rush), *Drosera intermedia* (Narrow-leaved Sundew), *Juncus pelocarpus* (Brown-fruited Rush), *Myriophyllum tenellum* (Water-milfoil), *Muhlenbergia uniflora*, *Potamogeton confervoides, P. oakesianus*, *Utricularia cornuta* (Horned Bladderwort), *and Viola lanceolata* (Lance-leaved Violet) are frequently conspicuous in sites supporting coastal plain disjuncts.

Lastly, there are species considered by Peattie (1922) and/or McLaughlin (1932) as coastal plain species, but which are much more widespread, although ecologically they may be a prominent component of the flora on lakes such as Axe Lake. Species such as *Calamagrostis canadensis* (Blue-joint), *Dulichium arundinaceum* (Three-way Sedge), *Eriocaulon septangulare* (Pipewort), *Lycopodium inundatum* (Bog Club-moss), *Lycopus uniflorus* (Water-horehound), *Pontederia cordata* (Pickerel weed), *Rhynchospora fusca* (beak-rush), *Scirpus torreyi* (bulrush), and *Utricularia gibba* (Humped Bladderwort) are probably best classified simply as species of acid sands and bogs.

The restricted distribution of the following seven species results in their being classed as "rare" in Ontario (Argus and White 1977): *E. olivacea*, *J. militaris*, *P. oakesianus*, *R. virginica*, *R. capitellata*, *S. torreyi*, *X. caroliniana.*

Miller (1977) used floristic and water chemistry data to classify 56 lakes of southern Ontario into five "types," based on floating and submerged macrophytes. Axe Lake was included in his study and classified as type A, ". . . very soft, low conductivity lakes that are dominated by Isoetids and Utricularids . . .". These lakes generally have alkalinity values of 0–7 mg $CaCO_3 \cdot L^{-1}$ and conductivity values from 20–42 μS [μmhos]$\cdot cm^{-1}$. Miller reported that Axe Lake had an alkalinity of 3, conductivity of 29, and a pH value of 6. Miller did not provide the raw data matrix used in his floristic analysis, but based on his tables of "characteristic species," type A lakes are characterized by species such as *Lobelia dortmanna* (Water-lobelia). *E. septangulare, M. tenellum, U. purpurea, U. resupinata*, *J. pelocarpus*, *J. militaris*, and *Elatine minima* (Waterwort). Only the latter species has not been observed in Axe Lake. Crowder et al. (1977) studied 16 lakes in southeastern Ontario and similarly concluded that lakes with conductivities of below 60 $\mu s \cdot cm^{-1}$ contained species not found in other lakes, notably *E. septangulare*, *L. dortmanna*, and *M. tenellum*. Swindale and Curtis (1957) also found that species such as *M. tenellum*, *E. septangulare*, *J. pelocarpus*, and *E. minima* occurred together in low conductivity lakes in Wisconsin.

Vegetation

The most botanically interesting area of the lake is the extreme north end (Figure 2). The substrate ranges from the gently sloping sand shown in Figure 3 through to peat. This small area at the north end appears to encompass much of the variation in the shoreline types of Axe Lake.

Figure 4 shows shoreline profiles from the north end of Axe Lake in three different substrate types: (1) sand, (2) transition, and (3) peat. These categories are based on the organic content of the transects at 0.25 m above the waterline, as determined by weight loss on ignition to 400°C (mean values for each category are: sand = 0.9%, transition = 3.7%, peat = 16.4%). These changes in organic content are related to the physiognomy of the shoreline (Figure 4) and species composition (Table 1). These categories could be distinguished in the field. "Sand," as shown in Figure 3, referred to

FIGURE 3. The shoreline vegetation at the north end of Axe Lake in a sand shoreline type. Note the gently sloping sand exposed by falling summer water levels. The vegetation types from left to right (above to below waterline) are (1) *Betula papyrifera* (White Birch) and *Pinus strobus* (White Pine) forest, (2) a band of shrubs, principally *Myrica gale*, (3) open sand with *Rhynchospora fusca, Lobelia dortmanna, Eriocaulon septangulare, Drosera intermedia, and Utricularia cornuta* (at peak of flower — see lower left of picture), (4) emergents such as *Scirpus torreyi* mixed with *E. septangulare* and *L. dortmanna*, and (5) open water supporting *Scirpus subterminalis, Nympoides cordata, E. septangulare,* and *L. dortmanna.*

shorelines with extensive areas of open sand and only sparse plant cover. "Transition" shores were densely vegetated, but scattered openings in the vegetation revealed a sandy substrate. "Peat" shores were densely vegetated and had a peat layer covering the sand.

Sand was the least common of the three shoreline types, and occurred only on the north and east sides of the lake. (The latter has been disturbed by recent campsites, and possibly by a now-abandoned farm, so it was excluded from the study.) Peat shores were the most common of all. Transition areas intermediate in organic content were also common. These three categories are arbitrary divisions in a continuum, so a more accurate assessment of relative abundances of these shoreline types was not attempted. These categories are based only on above-water characteristics. The below-water organic content was consistently low (mean = 0.78%), yet, as Table 1 shows, the aquatic flora differed among the three shoreline types.

Species such as *N. cordata, E. septangulare,* and *M. tenellum* were abundant on areas of sand. All of the species in column 1 (except for *Juncus filiformis*) (rush) also occurred on more organic shorelines. In general, sand shorelines supported few species.

The transition shorelines supported many more species. *Rhexia virginica*, *X. caroliniana*, *M. uniflora*, and *V. lanceolata* attained their peak abundance on these shores. The dominant species included *Cladium mariscoides*, *E. septangulare*, and *N. cordata.*

The peat shorelines were dominated by *T. fraseri*, *Myrica gale* (Sweet Gale), *C. mariscoides*, *Scirpus subterminalis* (Swaying Rush), *E. septangulare*, and

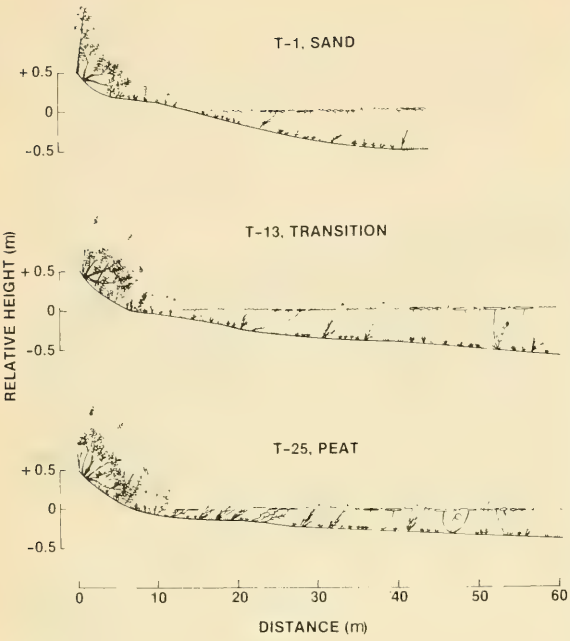

FIGURE 4. Diagrammatic profiles through transects representing the three main shoreline types studied. Note the increasing plant cover from sand through transition to peat shorelines.

N. cordata. Many floating-leaved aquatics, such as *B. schreberi*, *N. ordorata*. *Nuphar variegatum* (Yellow Pond-lily), and *Potamogeton oakesianus*, reached their peak abundance here. *Myriophyllum tenellum*, *L. dortmanna*, *U. cornuta*, and *J. pelocarpus* all decreased in frequency on peat shorelines.

Eleocharis olivacea did not occur in the study transects; this species and *X. caroliniana* reach their peak abundance on floating peat islands in the south end of the lake. *Woodwardia virginica* and *Rhynchospora capitellata* were also absent from the study area; each occurred at a single point elsewhere on the lakeshore.

Geological History

This area emerged from beneath the Wisconsin ice sheet roughly 12 000 years ago (Douglas 1970, fig. XII-15). Chapman (1975) stated that the absence of any strong moraines suggested an uneventful glacial withdrawal from the area. The glacier left behind sandy and stony till which is so thin that it generally fails to cover completely the underlying rock ridges. These ridges are composed of Precambrain granitic rocks (Hewitt 1967). A most interesting feature, however, is the postglacial Lake Algonquin shoreline which runs due north from Bracebridge to Lake Nipissing. This shoreline is now marked by extensive sand plains (Chapman 1975, map 2228). When Lake Algonquin was present, this shoreline possessed an intricate series of islands and bays (Figure 1). Axe Lake is just "off shore" from this maximum water level of Lake Algonquin. Lake Algonquin water levels then gradually dropped (because of new outlets such as the Fossmill outlet, as well as isostatic rebound) leaving behind scattered lakes with rich shoreline floras. At its peak the shoreline of Lake Algonquin may have had bays and islands with gently sloping sandy shores not unlike those on Axe Lake today.

Peattie (1922) attempted to trace the inland migration of coastal plain species in relation to the postglacial development of the Great Lakes. He concluded that the coastal plain flora entered the Great Lakes during the Lake Algonquin stage, when Lake Algonquin was drained by the Kirkfield outlet into Lake Iroquois, which in turn drained down the Hudson River to the Atlantic coastal plain. Speaking of this time, he wrote "Judging from the large number of old spits and beach ridges which have been traced out for the glacial lakes giving rise to Lake Erie and Lake Michigan, it is reasonable to imagine their shores to have been an intricate series of lagoons, ridges, strands and low dunes harbouring the newly-migrated coastal plain types." This appears to be an excellent description of the shoreline of Lake Algonquin from Bracebridge to Lake Nipissing.

McLaughlin (1932) noted that the greatest number of coastal plain plants grow on moist, sandy lakeshores, and that the development of *Sphagnum* bogs was partially responsible for the gradual elimination of these species. Figure 2 showed the extensive areas of peat bog around Axe Lake. These areas were presumably open water when Lake Algonquin was at its maximum; they have since become peat bogs, and judging from the extensive areas of boggy shores and floating peat islands in Axe Lake, this process is continuing. Many of the coastal plain species listed in Table 1 were absent from those shores of the lake with floating bog mats. On a smaller scale, comparison of column 2 (transition) with column 3 (peat) also appears to support McLaughlin's observation, as species such as *M. uniflora* and *R. virginica* are absent from peat shorelines. Aquatic coastal plain species, however, such as *P. confervoides*, *P. oakesianus*, *U. resupinata*, *U. purpurea*, and *J. militaris* reached their peak abundance in shallow water adjacent to the peat shores.

Recent History

Recent human activities, particularly cottage development, may be modifying many lakes in this area. To examine this problem, Miller and Dale (1979) studied changes in the aquatic macrophyte floras of eight small lakes in the Muskoka area. They

TABLE 1—Frequency of shoreline plants on three shoreline types in Axe Lake. Columns give percentage occurrence in "quadrats" located between 0.5 m above and 0.5 below the waterline. Species are arranged by (1) shoreline type of peak abundance (sand, transition, peat), (2) habitat specificity (number of shoreline types occupied), and (3) abundance. Shoreline types are shown in profile in Figure 4

Species	Occurrence along shoreline (%)		
	Sand (n = 120)	Transition (n = 240)	Peat (*n* = 140)
Sand			
Juncus filiformis	0.8	—	—
Viburnum cassinoides	6.7	0.8	—
Bidens sp.	1.7	0.4	—
*Nymphoides cordata**	70.8	56.7	43.6
Eriocaulon septangulare	65.0	57.1	43.6
*Myriophyllum tenellum**	41.7	26.3	12.1
Lobelia dortmanna	39.2	23.7	11.4
*Utricularia cornuta**	24.2	14.6	1.4
Hypericum boreale	10.0	9.2	2.9
Alnus rugosa	10.0	2.5	2.9
Spiraea alba	3.3	1.3	1.4
Transition			
*Rhexia virginica** †	—	14.2	—
Potamogeton natans	—	2.1	—
Lycopodium inundatum	—	1.7	—
Ilex verticillata	—	0.4	—
Carex michauxiana	—	0.4	—
Pyrus arbutifolia	—	0.4	—
Agrostis hyemalis	—	0.4	—
Panicum lanuginosum	—	0.4	—
Carex echinata	—	0.4	—
*Xyris caroliniana** †	6.7	14.2	—
Juncus brevicaudatus	1.7	4.2	—
Nemopanthus mucronata	3.3	3.3	—
Muhlenbergia uniflora	—	17.5	2.1
Utricularia gibba	—	7.5	7.1
Carex lasiocarpa	—	1.3	0.7
*Drosera intermedia**	16.7	39.2	14.3
*Cladium mariscoides**	3.3	39.2	30.0
*Juncus pelocarpus**	22.5	27.5	2.9
*Viola lanceolata**	4.2	25.8	3.6
Aster nemoralis	6.7	19.2	5.0
Scirpus torreyi†	1.7	19.2	12.1
Rhynchospora fusca	10.8	17.5	5.0
Transition (*continued*)			
Hypericum ellipticum	3.3	7.5	4.3
Juncus canadensis	1.7	2.9	0.7
Peat			
Potamogeton epihydrus	—	—	2.9
Iris versicolor	—	—	1.4
Chamaedaphne calyculata	—	—	0.7
Vaccinium oxycoccus	—	—	0.7
Dulichium arundinaceum	—	14.2	25.7
Eleocharis palustris	—	3.3	21.4
Calamagrostis canadensis	—	5.8	20.7
Brasenia schreberi	—	10.4	20.0
Nymphaea odorata	—	7.5	17.1
Rubus hispidus	—	7.9	15.7
Vaccinium macrocarpon	—	9.2	15.0
Nuphar variegatum	—	2.1	14.3
Pontederia cordata	—	3.3	13.6
Carex rostrata	—	4.2	12.1
*Potamogeton oakesianus** †	—	1.7	10.0
Glyceria canadensis	—	1.3	10.0
Carex vesicaria	—	1.7	5.7
Carex stricta	—	1.7	4.3
Utricularia intermedia	—	3.3	3.6
*Potamogeton confervoides**	—	0.4	2.9
Carex oligosperma	—	0.8	1.4
Scirpus subterminalis	15.0	40.4	50.7
Triadenum fraseri	9.2	20.8	35.7
Myrica gale	17.5	13.8	33.6
Lysimachia terrestris	20.8	20.8	31.4
Utricularia vulgaris	3.3	13.8	17.9
*Utricularia resupinata**	6.7	15.4	15.7
Lycopus uniflorus	10.8	6.7	13.6
*Utricularia purpurea**	1.7	8.8	12.1
*Juncus militaris** †	1.7	3.7	5.0

*Rare in Ontario (Argus and White 1977).
†Species with coastal plain affinities.

compared a 1953 survey of these lakes to their 1976 and 1977 surveys. Axe Lake, one of the lakes they studied, did not appear to have lost any species of aquatic macrophytes during this time period. Miller and Dale (1979) record nine additional species in Axe Lake; these were likely missed in the 1953 survey. In addition to their total of 19 species I collected *Potamogeton natans* (Floating Brown leaf), *P. confervoides*, *Glyceria borealis* (Small Floating Mannagrass), *J. militaris*, *J. pelocarpus*, *M. tenellum*, and *Zizania aquatica* (Wild Rice). Because the emphasis of this study was on shoreline and shallow water plants, additional species may yet be found. Local residents have remarked that the lake has become more weedy, but there is no convincing evidence of recent changes in the flora of Axe Lake.

In conclusion, Axe Lake appears to be a relict fragment of a once extensive sandy shoreline stretching from Bracebridge to Lake Nipissing. The flora of Axe Lake contains some coastal plain species which apparently migrated into the Great Lakes area near the end of the last ice age. The vegetation of this lake

may be a relict of the shoreline vegetation that flourished in the sandy bays of postglacial Lake Algonquin. Because the coastal plain flora of the Georgian Bay area has not yet been adequately recognized in planning parks and other reserves, it is to be hoped that thought will be given to preserving some suitable shores in the near future.

Acknowledgments

The assistance with summer field work by S. M. van Walsum and K. McCulloch was much appreciated. P. W. Ball (Erindale College, University of Toronto) and A. A. Reznicek (Herbarium, University of Michigan) kindly assisted in the annotation and determination of voucher specimens. Thanks also to R. Proctor for assistance with the data manipulation, and to D. F. Brunton, C. J. Keddy, G. La Roi, and A. A. Reznicek for constructive criticism of various drafts of this paper. G. Burger kindly permitted us to work on his land and use his cabin for 1980 field work. This research was supported by University of Guelph R.A.B. grant No. 83193 and NSERC grant A6963.

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Received 3 June 1980
Accepted 12 December 1980

Low DDT Residues in Plasma of Bald Eagles (*Haliaeetus leucocephalus*) Wintering in Colorado and Missouri

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Henny, Charles J., Curtice R. Griffin, Dale W. Stahlecker, Alan R. Harmata, and Eugene Cromartie. 1981. Low DDT residues in plasma of Bald Eagles (*Haliaeetus leucocephalus*) wintering in Colorado and Missouri. Canadian Field-Naturalist 95(3): 249–252.

Residues of DDT and its metabolites (ΣDDT) in blood plasma from Bald Eagles (*Haliaeetus leucocephalus*) wintering in Colorado and Missouri were low (0.06–0.14 μg/g) in 1977 and 1978. Most of the adult wintering birds probably nest in Canada, although a few in Missouri may be from Minnesota or the Great Lakes region. DDE residues in eggs, estimated from those in plasma, were lower than those reported from Saskatchewan in 1969–1972 (4.5 μg/g vs. 0.67 μg/g); this suggests reduced environmental contamination.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*; environmental contaminants, DDT, PCB, wintering populations.

Reports of low rates of reproduction (Broley 1958; Abbott 1967) and relatively high levels of toxic chemical contamination (Krantz et al. 1970; Wiemeyer et al. 1972) in certain Bald Eagle (*Haliaeetus leucocephalus*) populations led to widespread concern for this species. It is classified as "endangered" in the contiguous states excepting Washington, Oregon, Minnesota, Wisconsin, and Michigan, where it is "threatened" (US Fish and Wildlife Service 1979). Sprunt et al. (1973) documented decreased reproduction in Florida, the northeastern states, and near the shores of the Great Lakes. Grier (1974) noted that many nesting birds are widely spaced in relatively inaccessible regions and thus are difficult to sample. To gain additional insight into the pollutant contamination of Bald Eagles, we collected blood samples for organochlorine analyses from two wintering populations, the San Luis Valley in Colorado and Swan Lake in Missouri, during the winters of 1976–1977 and 1977–1978.

Henny and Meeker (1981) showed that plasma residues could be used to predict residues in eggs for four species of raptors and that the relationship was species independent for the species tested. Furthermore, blood plasma residues in American Kestrels (*Falco sparverius*) paralleled residues in eggs during a recent study that evaluated the impact of an operational DDT spray project (Henny 1977a). The ability to predict residues in eggs provides a method for interpreting the plasma residues. Contaminants in plasma of adults and estimated contaminants in eggs from these two wintering segments of the Bald Eagle population can be evaluated because some information concerning residues in Bald Eagle eggs is available.

Methods

During the study 14 adults (white head) and 21 subadults were trapped and blood samples collected. Twenty were trapped in the San Luis Valley of Colorado between 22 January and 7 March 1977, and 15 at Swan Lake National Wildlife Refuge (NWR), Missouri, between 9 January and 16 February 1978. About 2–3 ml of blood was collected from the brachial vein with a 3-ml disposable syringe and a 23-gauge needle, then placed a heparinized tube, and kept cool until later in the day when it was centrifuged. The plasma was drawn off and stored frozen until it was analyzed at the Patuxent Wildlife Research Center.

The samples were mixed with anhydrous sodium sulfate, extracted 7 h with hexane in a Soxhlet apparatus, and lipids removed by Florisil column chromatography as described by Cromartie et al. (1975), except that the organochlorines were separated into four fractions rather than three to ensure the isolation of dieldrin or endrin, or both (Kaiser et al. 1980). The pesticides in each fraction were quantified with a gas–liquid chromatograph (GLC) using an electron-capture detector and a 1.5% OV-17/1.95% QF-1 column. Average recoveries ranged from 83 to 104% from spiked tissue and 77 to 97% from spiked Mallard

TABLE 1—Pesticide residues in plasma from Bald Eagles wintering in Colorado and Missouri

Location	Year	Mean residues (μg/g) ΣDDT[1]	Dieldrin	PCBs
Missouri				
4 adults	1978 (Jan.–Feb.)	0.06 (0.03–0.10)[2]	0.03 (ND–0.08)	0.24 (ND–0.36)
11 subadults	1978 (Jan.–Feb.)	0.06 (0.01–0.14)	0.01 (ND–0.06)	0.08 (ND–0.27)
Colorado[3]				
10 adults	1977 (Jan.-March)	0.14 (0.03–0.23)	0.01 (ND–0.05)	0.10 (ND–0.68)
10 subadults	1977 (Jan.-March)	0.07 (ND–0.31)	ND (ND)	0.04 (ND–0.36)

[1]Almost all DDE.
[2]Range; ND = none detected.
[3]Three contained heptachlor epoxide (0.11, 0.01, and 0.02), two contained *cis*-chlordane (0.02 and 0.01), and one *trans*-nonachlor (0.01).

(*Anas platyrhynchos*) blood. Residues were not corrected for percentage of recovery. The lower limit of reportable residues for organochlorine pesticides in the blood plasma ranged from 0.01 to 0.05 μg/g depending upon the sample size. Residues in 5% of the blood samples were confirmed with a Finnigan model 4000 gas chromatograph/mass spectrometer (GC/MS) (Kaiser et al. 1980).

Results and Discussion

The ΣDDT in plasma (mean 0.12 μg/g) of adult Bald Eagles was low (Table 1). Adult American Kestrels averaged nearly the same (ΣDDT 0.11 μg/g) before a spray project in the Pacific Northwest, while 1 year after a 3/4 lb per acre (0.84 kg/ha) treatment, they showed plasma levels of 0.78 μg/g in the spray area. Cooper's Hawks (*Accipiter cooperii*) and Sharp-shinned Hawks (*A. striatus*) in the same spray area averaged over 2 μg/g after spraying with some individuals showing 7–9 μg/g (Henny 1977a). The Bald Eagles in this study showed slightly higher ΣDDT plasma residues than found in 16 adult Golden Eagles (*Aquila chrysaetos*) (ΣDDT 0.02 μg/g) sampled near Dillon, Montana, in March, April, and May of 1975 (Henny, unpublished data). Adult Bald Eagles generally showed higher residues than the younger birds with the Missouri and Colorado populations carrying similar pollutant burdens.

The plasma residues (ΣDDT) in the Bald Eagle samples from this study were among the lowest encountered among adult raptors studied to date. We also converted the plasma residues to estimated egg residues based on the postlaying model of Henny and Meeker (1981). Estimated ΣDDT residues in eggs averaged 0.68 μg/g (Table 2). If the prelaying model were used, the residue estimates would be slightly lower. Polychlorinated biphenyls (PCBs) were detected in five of the plasma samples; however, the detection limit was higher than for ΣDDT. Therefore, PCBs were probably also present at lower levels in other eagles.

One question immediately arises: Where are the nesting areas of the adult birds that winter in Colorado and Missouri? Whitfield et al. (1974) stated that Saskatchewan eagles must make up a large proportion of the population wintering in the midwestern United States. Recently, Gerrard et al. (1978) and Leighton et al. (1979) estimated the population in

TABLE 2— Pesticide residues in Bald Eagle eggs (μg/g) as estimated from plasma of adults

Location	No. samples	Estimated mean residues (range) ΣDDT	Dieldrin	PCBs[1]
Swan Lake, Missouri	4	0.36 (0.14–0.58)	0.15 (ND–0.43)	1.4 (ND–2.2)
San Luis Valley, Colorado[2]	10	0.81 (0.18–1.4)	0.05 (ND–0.26)	0.67 (ND–4.8)

[1]Minimal estimate.
[2]Two also contained small amounts of heptachlor epoxide and *cis*-chlordane, and one *trans*-nonachlor. ND = none detected.

TABLE 3—Toxic chemical residues (μg/g, fresh wet weight) in Bald Eagle eggs from Canada, Alaska, and the Great Lakes region, as compared to estimates from this study

Nesting location	Year(s)	No. eggs (No. nests)	DDE	DDD	DDT	Dieldrin	Heptachlor epoxide	PCB	Authority
Saskatchewan[1]	1969–1972	9	4.5	NA	NA	NA	NA	2.8	Gilbertson and Reynolds (1974)
NW Ontario[2]	1967	2	14	NA	NA	0.42	NA	NA	Grier (1974)
NW Ontario[2]	1968–1972	4	21	0.83	0.16	1.3	NA	87	Grier (1974)
Wisconsin[3]	1968	15(10)	4.7	0.32	0.06	0.37	0.02	NA	Krantz et al. (1970)
Michigan[4]	1969	1	39	1.1	ND	1.0	0.07	28	Wiemeyer et al. (1972)
Minnesota[3]	1969–1970	5(4)	9.6	1.0	ND	0.99	0.08	7.7	Wiemeyer et al. (1972)
Alaska, Kodiak[3]	1969	7(7)	1.9	0.12	ND	0.10	0.02	2.2	Wiemeyer et al. (1972)
Alaska, Admiralty Island[3]	1970	5(5)	2.9	T	ND	0.06	T	1.1	Wiemeyer et al. (1972)
This study	1977–1978	14	0.67	0.01	ND	0.08	T	0.89[5]	This study

NOTE: NA = not available, ND = none detected; T = trace.
[1]Geometric mean, dry weight basis, converted to fresh wet weight (divided by 5.0).
[2]Arithmetic mean, dry weight basis, converted to fresh wet weight (divided by 5.0).
[3]Arithmetic means computed on nest basis.
[4]Lake Superior site (high residues typical of Great Lakes) but not representative of Michigan eagle population at large, most of which is inland (S. Postupalsky, personal communication).
[5]Minimal estimate.

northern Saskatchewan at over 14 000 birds and showed band recoveries which bracketed the Colorado and Missouri wintering areas. Griffin et al. (1980) reported that Bald Eagles that wintered at Swan Lake NWR in Missouri originate in Ohio, Michigan, Wisconsin, Minnesota, Ontario, and Saskatchewan, and some migrate through Manitoba and Ontario. Dunstan (1973) reported two Minnesota-banded birds recovered in Texas, that probably had migrated through Missouri. Postupalsky (1976) reported recoveries from Michigan-banded eagles generally to the east of Missouri except for one in Arkansas.

S. Postupalsky et al. (Department of Wildlife Ecology, University of Wisconsin, Madison, Wisconsin, unpublished data) pointed out that adults that breed in Minnesota and western Ontario and points north and northwest apparently are migratory, but few if any that nest south of Lake Superior leave their summer range during the winter. Thus, a subadult found in the winter at Swan Lake could have hatched anywhere between Saskatchewan and northern Ohio. An adult, on the other hand, would most likely be from Canada or possibly Minnesota.

Chemical residue levels in a few Bald Eagle eggs from Alaska, Canada, and the Great Lakes region have been published (Table 3). Residues in Saskatchewan and Alaska in 1969–1972 were among the lowest reported. Most Bald Eagle eggs analyzed were addled and therefore may not be representative (i.e. eggs with higher residues may not hatch, but eggs with extremely high residues may break). Postupalsky (1978) recently reported improved eagle productivity in the Great Lakes region. Bald Eagles appear to be following the same pattern of improvement in reproduction with the decline of DDE residues as the Osprey (*Pandion haliaetus*) (Henny 1977b; Spitzer et al. 1978).

The improved pattern of productivity in several Bald Eagle populations in the mid-to-late 1970s suggest that our estimated egg residues in 1977–1978 (0.67 μg/g DDE) are realistic and that a residue decline did occur in the Canadian breeding population (cf. Saskatchewan, 4.5 μg/g DDE in 1969–1972). Leighton et al. (1979) reported a reproductive rate of 0.95 young per breeding area in Saskatchewan in 1974 and indicated the production was well above the best estimate of the minimum required to maintain a stable population (0.7 young per occupied breeding area) determined in studies of six other Bald Eagle populations (Sprunt et al. 1973). It should be noted that the plasma–egg relationship for ΣDDT in Bald Eagles has not been studied specifically. We are assuming that the relationship is independent of species; therefore, it would be useful to collect a few eggs from Bald Eagles

nesting in northern Canada to determine if egg residues agree with our predictions.

Acknowledgments

The Colorado portion of the study was partially supported by the National Wildlife Federation and the National Audubon Society. The Missouri portion of the study is a contribution from the Missouri Cooperative Wildlife Research Unit; it was funded in part by the Unit, by a National Audubon Society fellowship, and by the US Fish and Wildlife Service through Agreement No. USDI 14-16-008-757, awarded to the University of Missouri. The manuscript was improved by the comments of Sergej Postupalsky, Thomas S. Baskett, and Lucille F. Stickel.

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Received 10 November 1980
Accepted 14 January 1981

Changes in Small Mammal Populations Following Clear-cutting in Upper Michigan Conifer Swamps

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Verme, Louis J., and John J. Ozoga. 1981. Changes in small mammal populations following clear-cutting in upper Michigan conifer swamps. Canadian Field-Naturalist 95(3): 253–256.

Strip clear-cutting in an upper Michigan conifer swamp increased the relative abundance of small mammals, particularly Deer Mice (*Peromyscus maniculatus*), Least Chipmunks (*Eutamias minimus*), and Meadow Voles (*Microtus pennsylvanicus*). Compared to a clear-cut block with slash left unburned, broadcast burning of slash resulted in a greater population of shrews (mainly Masked Shrews, *Sorex cinereus*) and Deer Mice. Nevertheless, because Northern White Cedar (*Thuja occidentalis*) reproduced adequately, we conclude that small rodents have little impact upon conifer swamp regeneration in this locale.

Key Words: small mammals, Northern White Cedar, *Thuja occidentalis*, clear-cutting, stand regeneration.

Conifer swamps dominated by Northern White Cedar (*Thuja occidentalis*); occupy over a million acres in Michigan's upper peninsula, or nearly half of this forest type's acreage within the northern Great Lakes region (Johnston 1977). These stands are vital to White-tailed Deer (*Odocoileus virginianus*) because they congregate, or "yard," here in winter to gain respite from harsh weather. Efforts to restore conifer swamp deeryards to their former high carrying capacity involve systematic clear-cutting of timber to produce a series of even-aged stands (Verme 1965). Under certain conditions, broadcast burning of the logging slash constitutes a valuable silvicultural tool in conifer seedbed preparation (Johnston 1977).

Clear-cutting and burning of swamps conceivably could create ideal environments for small rodents and lead to serious depredation on conifer seeds and/or seedlings, thereby hindering or even preventing stand reestablishment. Surprisingly little is known about small mammal populations inhabiting the White Cedar forest type (Manville 1949; Verme 1958; Ozoga and Verme 1968). The purpose of this study was to document changes in species composition and relative abundance of small mammals following clear-cutting to assess their potential impact on cedar regeneration.

Study Areas and Methods

This study was conducted in the Petrel Grade deeryard, which is situated 5.8 km northeast of Shingleton, in Alger County, Michigan (46°34′N, 86°37′W). The area lies in the cold, deep, snow belt along the south shore of Lake Superior. The two sites investigated were about 1 km apart and comprised readily accessible portions of an irregular-shaped 100-km^2 conifer swamp. Both areas, before logging, were densely timbered chiefly in mature (100–200 yr old) White Cedar, with Black Spruce (*Picea mariana*) and Balsam Fir (*Abies balsamea*) as minor associates. Logging of the first site began in the 1965–1966 winter and consisted of clear-cutting alternate strips 33–50 m wide aligned east–west. Cutting progressed in a southerly direction, with the initial series of clear-cutting being completed in two winters. Subsequent removal of the residual strips began in the 1975–1976 winter and was completed in 3 years.

Small mammal populations were studied by means of snap traps (mainly Museum Specials) baited with peanut butter during a 2-wk period in late August and/or early September from 1967 to 1977, excluding 1974. Because the cutting area initially was rather small, in 1967 we established four parallel traplines spaced about 44 m apart. On each line two traps were placed at either edge of a clear-cut strip, with another two set equidistant (±15 m) apart within the cleared portion and residual stand, respectively. Thereafter, two 750-m-long traplines were used, spaced 110 m apart. The traplines were shortened in 1976 and especially 1977, as cutting of the residual strips neared completion; hence, fewer trap nights of effort resulted, because the original spacing was retained. A 440-m trapline established parallel to and 550 m east of the clear-cut unit served as a control, but it was abandoned after the area was also logged, in 1973.

Because the number of small mammals captured was not based on equal trap nights among units, statistical analysis employed logarithmic transformations of results to test skewed data containing zeros (Elliot 1971). The transformed data by species by year were then tested by analysis of variance to appraise differences among microhabitats.

The second study area consisted of a 4-ha neck of conifer swamp bordered on one side by northern hardwoods and grading into a mixed forest type on the other side. The stand was clear-cut within 2 yr, beginning in the 1971–1972 winter. In May 1973, half of the unit was broadcast burned to eliminate slash; all tree limbs less that 7.5 cm in diameter were consumed by the hot fire. A rectangular (65 × 105 m) trapline

was established in each unit in 1974 and run for 2 wk in late summer annually through 1977. Traps were spaced 10 m apart around the perimeter of each line. One corner of the slash-burned trapline extended to within 50 m of adjacent northern hardwoods; however, at least a two-fold greater buffer zone existed between the remaining portion and its proximity to the edge of another forest type.

A three-way contingency table (Kullback et al. 1962) was used to analyze the catch data by species according to site treatment (i.e., slash burned or unburned).

Results

Strip Clear-cut

Compared to the uncut control, strip clear-cutting collectively produced twice as many ($P < 0.001$) small mammals during the 7-yr study, 8.9 vs. 4.6/100 trap nights (Table 1). Logging resulted in an eightfold greater abundance of Deer Mice and Meadow Voles. Relative abundance of Least Chipmunks (*Eutamias minimus*) and Northern Flying Squirrels (*Glaucomys sabrinus*) increased nearly fourfold following logging. Southern Red-backed Voles (*Clethrionomys gapperi*) doubled in number on clear-cuts, whereas Masked Shrews (*Sorex cinereus*) were slightly more numerous in the control site. Conifer swamps in this locale apparently do not provide suitable habitat for Bog Lemmings (*Synaptomys cooperi*) or Meadow Jumping Mice (*Zapus hudsonius*) as few were captured. Red Squirrels (*Tamiasciurus hudsonicus*) were common in the area, but proved difficult to catch in the Museum Specials.

There was no difference ($P > 0.05$) in population levels of small mammals captured within the residual stands, cleared strips, or their contiguous edges. However, certain species demonstrated rather distinct habitat preferences (Table 2). Their general distribution was consistent with known living requirements for a given species. For example, Southern Red-backed Voles definitely preferred uncut timber, whereas Meadow Voles were mainly found in the cleared strips.

TABLE 1—Variation in small mammal abundance in a strip clear-cut versus an uncut conifer swamp in upper Michigan over a 7-yr period

Species	Strip clear-cut site	Uncut site
Deer Mouse	2.9(135)[a]	0.4(5)
Southern Red-backed Vole	1.6(76)	0.8(11)
Meadow Vole	0.7(31)	0.1(1)
Bog Lemming	0.1(1)	0.1(1)
Meadow Jumping Mouse	—	0.1(1)
Least Chipmunk	1.3(62)	0.4(5)
Northern Flying Squirrel	0.3(12)	0.1(1)
Red Squirrel	0.1(1)	—
Masked Shrew	2.1(100)	2.6(37)
Short-tailed Shrew	0.1(1)	0.1(2)
Total catch	8.9(419)	4.6(64)
Total trap nights	4712	1400

[a]Data are means/100 trap nights; total animals snap-trapped are shown in parentheses.

TABLE 2—Influence of conifer swamp microhabitat on small mammal abundance in upper Michigan

Species	Clear-cut strip interior	Clear-cut/uncut edge	Uncut strip interior
Deer Mouse	2.1(40)[a]	1.7(35)	3.5(68)
Southern Red-backed Vole	0.5(10)	1.2(24)	3.3(65)
Meadow Vole	1.3(25)	0.5(10)	0.3(5)
Bog Lemming	—	0.1(1)	—
Meadow Jumping Mouse	0.1(1)	—	—
Least Chipmunk	1.4(27)	1.3(27)	0.6(12)
Northern Flying Squirrel	—	0.2(4)	0.5(9)
Red Squirrel	—	0.1(2)	—
Masked Shrew	2.7(51)	2.9(59)	2.1(41)
Short-tailed Shrew	—	—	0.2(4)
Arctic Shrew	0.1(2)	0.1(1)	—
Total catch	8.3(156)	8.1(163)	10.4(204)
Total trap nights	1883	2013	1971

[a]Data are means/100 trap nights; total animals snap-trapped are shown in parentheses.

Block Clear-cut-burn

Broadcast burning of slash in the block clear-cut area resulted in increased ($P < 0.05$) abundance of virtually all small mammals, yielding 15.1 animals/100 trap nights versus 9.4 where fire was not used (Table 3). The greatest proportional increase (nearly seven-fold) was manifested by Deer Mice; however, some of this increase could have been due to their influx into the burn from the adjacent northern hardwoods stand. Meadow Vole populations evidently were comparable on both units. Masked Shrews, Short-tailed Shrews (*Blarina brevicauda*), and Arctic Shrews (*Sorex arcticus*) were moderately more abundant in the burned unit. Least Chipmunks did not exhibit any marked preference for one site over the other. Although the burning of slash reduced useful escape cover, the prompt and rank establishment of fire-succession vegetation served effectively in this regard and apparently provided sufficient food for recolonization by the various small mammals. Meadow Jumping Mice, Woodland Jumping Mice

TABLE 3—Abundance of small mammals following clear-cutting with and without broadcast burning of slash in an upper Michigan conifer swamp

Species	Slash burned	Slash left
Deer Mouse	2.0(20)[a]	0.3(3)
Southern Red-backed Vole	0.5(5)	0.4(4)
Meadow Vole	2.8(29)	2.8(29)
Meadow Jumping Mouse	0.2(2)	0.1(1)
Woodland Jumping Mouse	0.1(1)	—
Least Chipmunk	1.9(19)	1.6(16)
Masked Shrew	5.6(57)	3.0(31)
Short-tailed Shrew	0.6(6)	0.2(2)
Arctic Shrew	1.5(15)	1.0(10)
Water Shrew	0.1(1)	—
Total catch	15.1(155)	9.4(96)
Total trap nights	1024	1024

[a]Data are means/100 trap nights; total animals snap-trapped are shown in parentheses.

(*Napaeozapus insignis*), and Water Shrews (*Sorex palustris*) were scarce in both areas.

Discussion

Our studies indicate that clear-cutting in White Cedar stands increased the relative abundance of many small mammals. The increase was somewhat greater when the resultant slash was broadcast burned compared to being left intact. Findings of major increases in small mammal numbers, especially Deer Mice, following clear-cutting with or without slash burning have been noted in other forest types (Trousdell 1954; Tevis 1956; Ahlgren 1966; Krefting and Ahlgren 1974; Hoovan and Black 1976; Martell and Radvanyi 1977). However, Sullivan (1979a) has argued that these increases primarily represent maximum autumn populations, and that densities at other seasons are far less because of habitat-limiting factors. We captured some species in environments where they would not be expected to occur. Perhaps such available habitats served as dispersal sinks for immature (subordinate) individuals during peak autumn density (Lidicker 1975; Sullivan 1977). Age classification of specimens we examined, however, was equivocal in this regard.

The natural increase or influx of seed eaters like the Deer Mouse and Least Chipmunk and/or plant eaters such as the Meadow Vole and Southern Red-backed Vole potentially could reduce or prevent regeneration of White Cedar after logging. However, examination of clear-cut and burned experimental plots bordering the first study area revealed there was more than adequate (>10 000 seedlings/ha) White Cedar 5 yr later (unpublished data). Thus, small mammal populations evidently had little effect on stand regeneration. White Cedar produces seed almost every year and a good crop every 3–5yr (Johnston 1977); hence germination is almost a continuous process.

Small mammal populations in conifer swamps in this locale experience dramatic fluctuations in abundance from year to year (Ozoga and Verme 1968). Any major "explosion" in rodent density from their usual comparatively low levels doubtless would attract a host of predators (including the ubiquitous shrews) which would help keep the numbers in check. Although Deer Mice inimically influence forest regeneration in other regions, Sullivan (1979b) notes that efforts to control their depredations have failed because of rapid immigration into vacant habitats from surrounding areas. Application of proper silvicultural techniques quite likely is the key to adequate regeneration of White Cedar (Johnston 1977). No artificial measures to control prospective damage by small mammals seem warranted in conifer swamps of upper Michigan. The main wildlife damage to cedar reproduction is due to excessive browsing by White-tailed Deer and Snowshoe Hare (*Lepus americanus*) populations (Bookhout 1965); their destructive influence can be regulated by hunting, plus sound deeryard management practices (Verme 1965).

Acknowledgments

This paper is a contribution from Federal Aid in Wildlife Restoration Project W-117-R, Michigan, and the Cusino Wildlife Research Station. We thank G. E. Burgoyne for assistance in statistical analysis; C. S. Bienz, D. L. DeLisle, and L. J. Perry also aided in this endeavor. W. F. Johnston and R. H. Baker graciously reviewed the manuscript.

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Received 26 September 1980
Accepted 27 January 1981

Nest-tree Sharing by Herons and Cormorants in Montana

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Thompson, Larry S. 1981. Nest-tree sharing by herons and cormorants in Montana. Canadian Field-Naturalist 95(3): 257–260.

At two central Montana colonies where Great Blue Herons (*Ardea herodias*) and Double-crested Cormorants (*Phalacrocorax auritus*) share nest trees, herons arrived about three weeks earlier than cormorants and selected sites in healthy trees near the center of the colony. Cormorants often used vacant nests or recently abandoned heron nests, sometimes in the same tree as nesting herons. No evidence was seen of vertical stratification of nest sites by species, of nest eviction, or of competition for nest sites. Opportunistic use of old heron nests by cormorants may reduce energy expenditures in nest-building and allow speedier onset of reproduction.

Key Words: Great Blue Heron (*Ardea herodias*) , Double-crested Cormorant (*Phalacrocorax auritus*), nesting, colonial, Montana.

Arboreal mixed nesting colonies of colonial water birds have been well documented in North America. In Atlantic wetlands, five or more species may be found nesting within a single tree. Several workers (e.g., Jenni 1969; McCrimmon 1978) observed nest-site stratification and inter- and intra-specific competition for nests in mixed heron colonies. There has been little documentation of interspecific aggression or competition for nest sites between ardeids and water birds of other orders.

In the northern Great Plains and adjacent Rocky Mountains, the only large colonial water birds which commonly nest in trees are the Great Blue Heron (*Ardea herodias*) and the Double-crested Cormorant (*Phalacrocorax auritus*). Lewis (1929) and Gersbacher (1939) noted no apparent interspecific aggression or competition for nest sites in mixed heron–cormorant colonies. The relative positions of heron and cormorant nests vary; Gersbacher (1939) reported cormorants nesting on the highest treetops in a mixed colony in Tennessee, whereas in Saskatchewan the cormorants nested lower than herons (Vermeer and Anweiler 1970). Of the 15 known arboreal cormorant colonies in Montana, 12 also had herons, and the two species often nested on the same branch (Thompson 1978).

During the spring and summer in 1976–1978, I observed mixed colonies in Montana to gain insight on the following questions: Do herons and cormorants compete for nest sites? Do mixed colonies merely result from limited nest site availability, or do the two species actively seek each other out? If the latter, what adaptive advantages are conferred by sharing of nest trees or mixed colonies?

Study Area and Methods

Two mixed heron-cormorant colonies in Montana, at Lake Helena and Townsend, were selected for close study. I also made some observations in four other mixed colonies. The Lake Helena colony (46°41′N, 112°57′W) is located near the inlet of Tenmile Creek into Lake Helena, a 200-ha impoundment on the Missouri River. Herons have nested there since about 1935, but cormorants only in 1975 (S. Martin, 1110 Wilder Avenue, Helena, Montana, personal communication) and 1976. The Townsend colony (46°21′N, 111°31′W) is on an island in the Missouri River 2 km upstream from Canyon Ferry Reservoir. Herons and cormorants have shared this colony for many years (S. Martin, personal communication).

During the nesting seasons of 1976–1978, 47.6 h were spent observing behavior of birds. Most field time was spent at Lake Helena in 1976, when the group of trees harboring both heron and cormorant nests was observed with a 20× telescope for 33.5 h during March through July. Between 17 April and 15 May 1976, 7.5 h were spent recording the exact occupancy of each nest and the movements and behavior of nesting birds. Relatively little time was spent at this colony in 1977 and 1978 because cormorants were not nesting there. The townsend colony could not be studied in as much detail owing to the inaccessibility of the island.

Results

Nest Distribution and Habitat

Lake Helena colony. Most heron nests were situated at heights of 12–18 m in the tops of old willows (*Salix* spp.). The only trees shared by herons and cormorants were three adjacent willows, with many dead branches, about 250 m from the main colony (Figure 1). All nests shown, except No. 12, were present before birds arrived in 1976. Each tree had one active heron nest for at least part of the 1976 season. One heron and eight cormorant nests in this group of trees success-

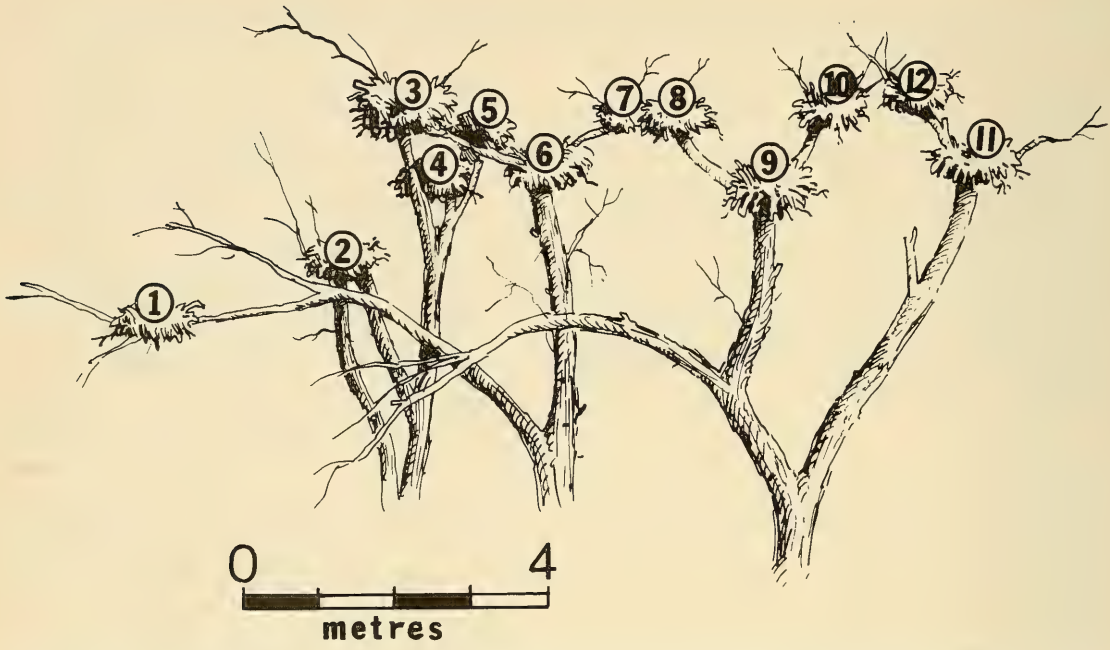

FIGURE 1. Relative position of nests in trees occupied by both herons and cormorants at Lake Helena. In 1976, cormorants occupied nests 2, 5, 6, 8, 9, 10, 11, and 12, and herons occupied nests 1 and 3. Nest 11 was occupied by herons early in the season but was later taken over by cormorants.

fully fledged young in 1976, but no active nests of either species were found here in 1977 or 1978.

Townsend colony. Both herons and cormorants shared nest trees in the Townsend colony during all three years of this study. In 1978, at least 43 heron and 24 cormorant nests were active. Nests were located near the tops of Black Cottonwoods (*Populus trichocarpa*) 14–19 m high. Most cormorants nested in dead or dying trees with little foliage near the edge of the colony, although some nested with herons in densely leafed-out trees near the center of the colony. As at Lake Helena, no apparent horizontal or vertical stratification of nests was observed. One tree, which supported two heron and five cormorant nests in 1976, supported nine active cormorant nests and no herons in 1978. Some trees not used in 1976 had nests of one or both species in 1978. At least seven trees supported both heron and cormorant nests in 1978.

Nesting Chronology and Behavior

Lake Helena colony. During the three years of the study, herons first began using nests in late March; by the first week of April, most herons had arrived. The earliest arrivals selected old nests in the center of the main colony. In 1976, pairs were first seen on 22 March. The peak of display, courtship, and territory establishment was around 27 March – 10 April. Incubation extended through late April and early May, and fledging occurred from mid-June until mid-July. Herons started nesting later in that portion of the colony later occupied by cormorants, perhaps because the open, nearly dead trees offered less security.

In 1976, the first two cormorants were seen on 15 April. By this time, herons at the main colony were mostly paired and well into incubation, and nests 1, 3, and 11 (Figure 1) were occupied by herons. Nest 6 was claimed by a cormorant almost immediately, and three pairs were present by 21 April. By 1 May, nest 11 had been abandoned by the lone heron and claimed by a cormorant; nests 2, 6, 8, 9, and 10 were also occupied by cormorants. The peak of cormorant courtship display was between 21 April and 1 May. Between 1 May and 15 May, a new nest (No. 12) was built and occupied by a cormorant; nest 5 was also occupied. No further changes occurred, and by 10 July, two young herons were present at nest 3 and young cormorants (two to five per nest) in each of the eight occupied nests. Herons were last seen in nest 1, which was unsuccessful, on 12 June.

Townsend colony. Both species arrived at the Townsend site a few days ahead of the Lake Helena arrivals. In 1976, herons and cormorants were first seen in nest trees on 20 March and 10 April, respectively.

Territoriality and Interspecific Aggression

While cormorants exhibited much intraspecific aggression, no displays were obviously directed at neighboring herons. Herons, on the other hand, were observed giving the following displays in apparent response to nearby cormorants: forward (twice), arched neck (once), snap (four times), and fluffed neck (once). (Nomenclature of heron displays follows that of Mock (1976).) No direct evidence of interspecific supplanting or evicting of an occupant from an established nest was obtained, although, as noted before, the unpaired male heron at nest 11 at Lake Helena was replaced by a cormorant. During 1978, four heron nests were taken over by cormorants at Townsend. I noticed no replacement of cormorants by herons at nest sites during a breeding season, although M. Bishop (Polson, Montana, personal communication) reported this at Ninepipe National Wildlife Refuge in western Montana.

Discussion

The observed sharing of nesting colonies by herons and cormorants may simply be a chance association forced by shortage of suitable nesting habitat. This is unlikely, because suitable nesting sites—tall deciduous trees near large bodies of water—are abundant throughout Montana, and yet the degree of association is considerable. Sharing of colonies and nest trees might therefore confer some advantage on one or both species. Because herons arrive at colonies nearly a month earlier and are well entrenched by the time the cormorants arrive, the latter are likely to be both the instigators and the main beneficiaries of the association. Krebs (1978) discussed two possible advantages of group nesting: protection from predation and facilitation of food exploitation. However, these are not likely explanations for colony sharing by herons and cormorants.

Cormorants are much more reactive to approaching humans than are herons; they would often flush from nests when I approached within 200 m, whereas herons would show no response until I came within 70 m. The predator-detecting ability of herons would do cormorants little good, especially because the most significant potential predators in the area are other birds. By the "information center" hypothesis of Ward and Zahavi (1973), coloniality affords easier location of food items through cooperative food searching or interspecific learning of feeding areas. Herons and cormorants, however, obtain different food items by quite different means and seldom feed in the same portion of a water body.

Cormorants that use vacant heron nests in an established colony reduce the amount of time and energy spent in nest construction, and can reproduce more quickly. This may well provide an advantage over cormorants constructing new nests. Although 67–93% of nests in heron colonies in Oregon and Montana are occupied each year (Werschkul and McMahon 1976; Thompson 1978), the other nests are available for immediate occupancy by cormorants arriving in late spring. Pair formation in cormorants begins immediately upon arrival at Montana colonies; this could indicate a selective pressure for speedy reproduction upon arrival at nesting grounds. Jenni (1969) and McCrimmon (1978) have documented a drastic contraction of defended territory around heron nests as incubation gets under way; by the time cormorants arrive in mid-April, nests in the same tree or on the same branch as active heron nests may be occupied with little interspecific strife. Where the temporal separation between heron and cormorant nesting peaks is less than in the northern Great Plains, occupancy of nests adjacent to territorial herons would be more difficult, and the incidence of nest-tree sharing would be lower. This may be the case, in light of the rarity of published accounts of nest-tree sharing.

Cormorants arriving in Montana in spring probably select arboreal nesting colony sites in response to a number of environmental cues, including: (1) presence of active heron colonies, which indicates relative safety of nest sites from predators; (2) presence of vacant nests, which allow speedier onset of nesting; (3) presence of nearby large water areas, which indicates a stable food source; (4) water surrounding the nest trees or the land on which the trees are located, which means safety of fledged young from ground predators. Cormorants may thus let herons do part of the work of locating and constructing nests in suitable colony sites.

Because the first herons arriving at a colony generally select the choice sites in the centre of the colony, most of the surplus nests are located at the colony's edge, often in dead or dying trees. This may explain the apparent preference of cormorants in Montana for nest sites in partly bare trees near the edges of heron colonies.

Thus, there appears to be no competition between herons and cormorants in selection of nest sites, nor vertical stratification of nest sites in trees. This sharing of nest trees is likely to have arisen as an opportunistic relationship benefiting cormorants considerably and herons slightly.

Acknowledgments

Many thanks are due to S. Martin and G. Holton, who first alerted me to the phenomenon of nest-tree sharing at Lake Helena and who provided continuous advice and encouragement; and to C. Winterburn and his wife who kindly allowed me access to the Lake

Helena colony. I also thank many others who shared their knowledge of herons and cormorants in Montana. Special thanks to my wife Susan for sharing ideas and field work and for her invaluable tactical and moral support. D. Chitty, D. McCrimmon, D. Mock, and K. Vermeer provided helpful comments on earlier versions of this manuscript.

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Received 14 December 1979
Accepted 23 January 1981

Occurrence and Growth Patterns of the American Brook Lamprey, *Lethenteron lamottenii*, in the Ottawa River

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Lanteigne, J., J. M. Hanson, and S. U. Qadri. 1981. Occurrence and growth patterns of the American Brook Lamprey, *Lethenteron lamottenii*, in the Ottawa River. Canadian Field-Naturalist 95(3): 261–265.

Ammocoetes, transforming ammocoetes, and adults of the American Brook Lamprey, *Lethenteron lamottenii*, are reported for the first time from the Ottawa River. Specimens were caught only from the sandy areas of three islands when the water temperature was between 13 and 25°C. Lampreys were not present in the shallow water (< 1.1 m) when water temperatures were less than 10°C. The largest ammocoete captured was 198 mm long and weighed 10.4 g. The prebranchial and branchial lengths (as a percentage of total length) became proportionately shorter as length increased and the trunk and tail lengths became proportionately longer with increasing length. This showed that morphometric characters undergo changes particularly during early larval life. The length–weight relationship, log WT = 2.819 log TL – 5.467, and the decrease in the values for the Fulton's condition factor with increasing length further demonstrate that growth was allometric.

Key Words: lamprey, ammocoetes, *Lethenteron lamottenii*, body proportions, condition, length-weight, pigmentation, habitat, Ottawa River.

The American Brook Lamprey, *Lethenteron lamottenii*, occurs in Canada in streams flowing into the St. Lawrence River, Lake Champlain, in the Great Lakes (other than the eastern portion of Lake Ontario), and in the Noire, St. Anne de la Perade, and St. Maurice Rivers of Quebec (Scott and Crossman 1973). Vladykov (1972) reported its occurrence in the Gatineau River (a tributary of the Ottawa River) below the Petites Chutes at Limbourg, Quebec, where 10 adults were collected on 17 May 1959. No other collections have been made since then in the Ottawa or Gatineau rivers.

The purpose of this study is to report the first occurrence of the American Brook Lamprey in the Ottawa River and to describe some aspects of its growth.

Materials and Methods

American Brook Lamprey were collected with a backpack electrofisher (type VII, Smith-Root Inc., Vancouver, Washington) in the shallow water of the Ottawa River near Ottawa, Ontario. Sampling was done along the north and south shorelines of the Ottawa River, in all small creeks flowing into the river, and around Kettle Island, Upper Duck Island, and Lower Duck Island in an area from Lac Deschenes to just east of Lower Duck Island (Figure 1). Additional sampling was done near the mouth of the Petite Blanche River (45°30′N, 74°32′W) and Green Creek (45°28′N, 74°33′W). The study area has been described by Ericksson (1974) and Hanson and Qadri (1980). Water temperatures reached 25°C in late July and early August 1979 in the shallow water around Upper Duck Island.

From samples collected at 2-wk intervals from 4 June to 7 November 1979, we kept 271 ammocoetes, 9 transforming ammocoetes, and 3 newly transformed adults. Additional sampling was done at 2-wk intervals from 5 May to 18 June 1980. Specimens were preserved in a 5% formalin solution and transported to the laboratory where total length (mm) and wet weight (to the nearest 0.01 g) of specimens blotted dry were recorded. The Fulton's condition factor, K(TL) (Hile 1941; Lagler 1956), was calculated for each specimen and the means and standard errors for 10-mm length-groups calculated. The length–weight relationship was determined for total length (mm) and wet weight (g) by the least squares method of linear regression (Ricker 1975). The mean values for the lengths of the prebranchial, branchial, trunk, and tail regions (as a percentage of total length) were calculated for 42 ammocoetes in 10-mm length-classes. The relationship of these same characters to total length were calculated by linear regression by the least squares method. Pigmentation patterns were recorded for the same 42 ammocoetes following the method described by Vladykov (1950). All specimens have been deposited with the National Museums of Canada Ichthyological Collection (NMC 80: 958–962).

Results

American Brook Lamprey were not captured in the Ottawa River, or its small tributaries, above the Chaudière Falls. Specimens were not caught along the shorelines or from the small tributaries of the Ottawa River below the Chaudiere Falls, but ammocoetes were common around Kettle Island, Upper Duck Island, and Lower Duck Island.

The shorelines of the islands differ from the shore-

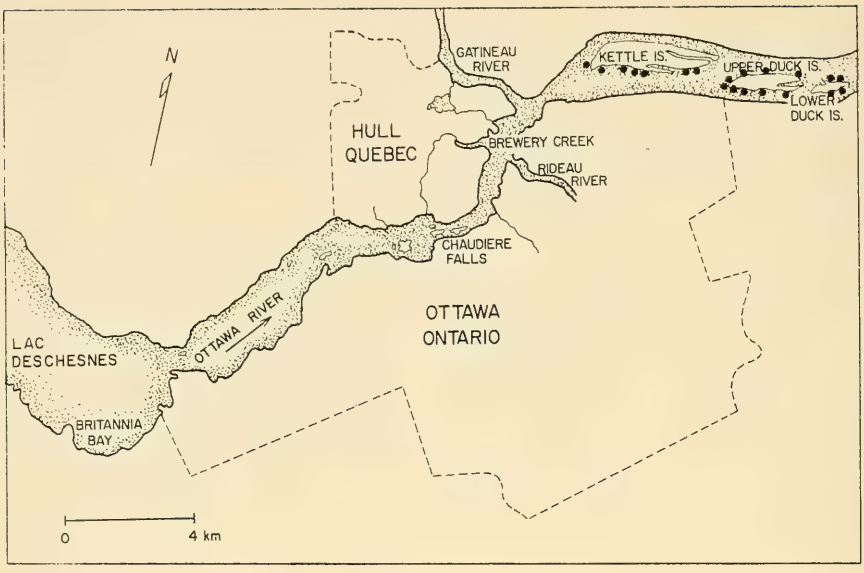

FIGURE 1. Sampling sites where *Lethenteron lamottenii* was collected in the Ottawa River, Ottawa–Hull area.

lines of the main river channel in that the substrate of the former is mostly sand and the substrate of the latter is mostly clay. Ammocoetes were not collected from the eastern tip of Kettle Island which has a hard clay substrate nor were there any present along the north shoreline of Kettle Island which is subjected to pollution and dredging activities by the Canadian International Paper Company at Gatineau, Quebec.

The large ammocoetes, transforming ammocoetes, and newly transformed adults were usually taken among the emergent vegetation in depths less than 0.3 m. Lampreys were not present in the shallow water (<1.1 m) after temperatures decreased to 10°C in October 1979, but ammocoetes were present in the shallow water on 5 May 1980, when the water temperature was 16°C.

The upper lip and suborbital areas of 42 American Brook Lamprey ammocoetes were devoid of pigment and the prebranchial blotch was absent. The branchial region above the branchial openings was without pigment for about 2 mm, leaving a whitish band below the dorsal pigmented area. The pigmentation on the caudal fin varied from weak to moderate; an unpigmented margin was always present. At capture, the newly transformed adults were yellow-brown on the dorsal surface and the sides and the ventral surface were silver-grey. The number of trunk myomeres ranged from 65 to 70 (usually 68) for 42 ammocoetes. The three adults had 69, 70, and 71 myomeres. The values obtained for the body proportions of 42 ammocoetes divided into 10-mm length-groups showed the changes occurring in the different body areas throughout larval life. The prebranchial and branchial regions became proportionately shorter with increasing body length, this process occurring more rapidly in the smaller length-classes, and leveling off at about the 140- to 149-mm length-class (Figure 2). The relative lengths for the trunk and tail regions increased with total length and leveled off somewhat at about the 140- to 149-mm length-class (Figure 3). After 160–169 mm, there seemed to be a slight decrease in the relative length of the trunk region and a slight increase in the tail region.

The total length of the 271 ammocoetes and 9 transforming ammocoetes had a range from 60 to 198 mm and 134 to 202 mm, respectively. The three newly transformed adults were 146, 166, and 181 mm in total length. The linear regression fitting the data for length and weight of ammocoetes was log WT = 2.819 log TL − 5.467, $n = 271$, $r = 0.9947$. As the slope of the length–weight relationship shows that the weight is proportionately less as length increased, the values for Fulton's condition factor should decrease as the ammocoetes grow. The values for Fulton's condition factor decreased from a value of 0.185 for the smallest ammocoetes to a value of 0.129 for the longest ammocoetes (Figure 4).

Discussion

The typical habitat of *L. lamottenii* was described by Vladykov (1949) as cold brooks and small rivers, usually in association with Slimy Sculpin (*Cottus cognatus*) and Brook Char (*Salvelinus fontinalis*), and by Morman (1979) as pool–riffle streams with low

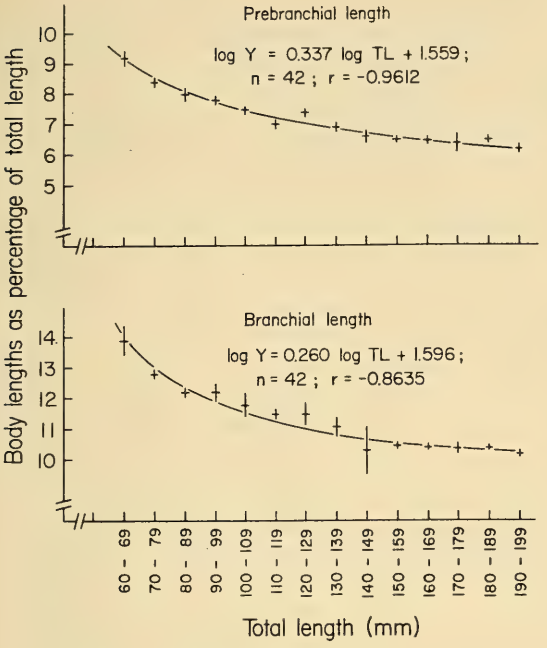

FIGURE 2. Mean value for the relative length of the prebranchial and branchial regions of *Lethenteron lamottenii* for each 10-mm ammocoete length-group.

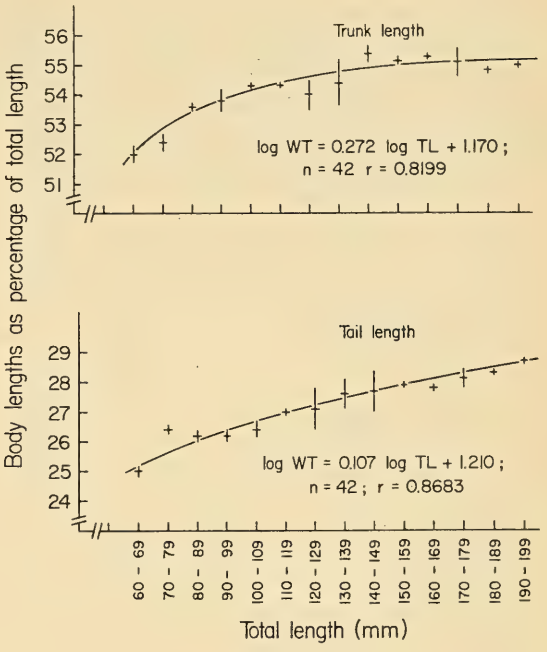

FIGURE 3. Mean value for the relative length of the trunk and tail regions of *Lethenteron lamottenii* for each 10-mm ammocoete length-group.

temperatures and stable bottom. In Delaware, habitats occupied varied from mud to sand at the Coastal Plain localities to clay and gravel at the Piedmont localities with water temperatures ranging from 9.0 to 12°C (Rohde et al. 1976). The Ottawa River population differs in that it inhabits a large river, and the ammocoetes were only found in the sandy areas of three large islands when water temperatures were between 13.0 and 25°C. The ammocoetes were not found in shallow water at temperatures below 10°C (mid-October) when, presumably, they had moved into deeper waters.

The patterns of pigmentation of the different body areas of the larval American Brook Lamprey from the Ottawa River correspond to the descriptions given by Vladykov (1950) for specimens collected in tributaries of the St. Lawrence River in Quebec.

Ammocoetes collected in Delaware apparently show proportionately longer tail and branchial lengths but shorter trunk lengths (Rohde et al. 1976) than the Ottawa River population (Table 1); specimens from Kentucky have similar branchial and tail lengths (Distler 1957). Such comparisons do not, however, show the ontogenic changes in body propor-

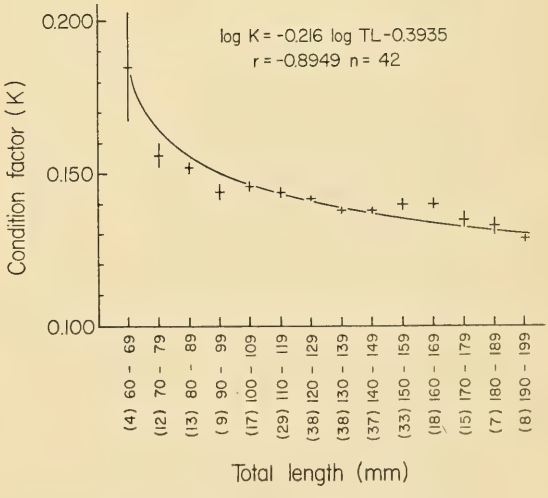

FIGURE 4. Condition factor of ammocoetes of *Lethenteron lamottenii* from the Ottawa River, Ottawa-Hull area. Means and 95% confidence limits are presented. Sample size in each 10-mm length-group is in parentheses.

TABLE 1—Comparison of the number of myomeres and body proportions (as a percentage of total length) of American Brook Lamprey from various drainages. Ranges, means, and number of specimens examined are presented

TL (mm)	No. of myomeres	Prebranchial length	Branchial length	Trunk length	Tail length	Location	Source
133–182	69–73	—	10.4–12.2	—	26.1–29.6	Greasy Creek,	Distler (1957)
158.0	70.8		11.4		28.0	Kentucky	
16	16		16		16		
—	65–74[a]	—	—	—	—	Big Creek,	Kott (1974)
	69.1					Ontario	
	303						
100–143	64–72[b]	—	12.6–14.4	51.0–53.7	27.7–31.6	Delmarva	Rohde et al. (1976)
121.0	68.0		13.3	52.0	29.7	Peninsula,	
19	101		19	19	19	Delaware	
—	63–70	—	—	—	—	St. Lawrence	Vladykov (1950)
	67.1					River, Quebec	
	381						
65–197	65–70	6.0–9.4	9.3–14.7	51.5–56.0	24.6–28.8	Ottawa River,	Present study
130.0	67.9	7.2	11.4	54.3	27.2	Ontario	
42	42	42	42	42	42		

[a]Adults only.
[b]Ammocoetes and adults combined.

tions relative to body length. The number of specimens studied from both the Delaware and Kentucky populations was small and only incuded a narrow (<50 mm) range of lengths. With the exception of the upper limit of the range for tail length for the Delaware population, the ranges of values reported for the body proportions of the Delaware and Kentucky ammocoetes fall within the range of values observed for the Ottawa River population. The average number of myomeres reported by Distler (1957) is higher than for other studies, but this is probably a sampling bias due to the small number of specimens examined. The range of the number of myomeres of ammocoetes from the Ottawa River readily falls within the range for the species (Vladykov 1950; Rohde et al. 1976).

The length–weight relationship for 139 ammocoetes of the American Brook Lamprey in Delaware was log WT = 2.76 log TL – 5.31 (Rohde et al. 1976). The relationship is very similar to that calculated for the lampreys in the present study. Rohde et al. (1976) did not calculate the condition factors for American Brook Lamprey, but they did calculate the condition factors for Least Brook Lamprey, *Lampetra aepyptera*, which has a length–weight relationship of log WT = 2.72 log TL – 5.24. They found a decrease in the value of the condition factors from 0.32 for the 11- to 20-mm length-group to 0.20 for the largest ammocoetes (121–130 mm). Hardisty (1944) also found that the value of the condition factor decreased with increasing length for *Lampetra planeri*. More studies are needed to determine if this pattern of allometric growth observed by Hardisty (1944), Rohde et al. (1976), and in the present study occurs with all lamprey ammocoetes.

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Received 19 September 1980
Accepted 2 February 1981.

A Time–Activity Budget for Breeding Mallards (*Anas platyrhynchos*) in Manitoba

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Individually marked Mallards (*Anas platyrhynchos*) were observed while breeding in pothole country near Minnedosa, Manitoba, in 1970 and 1971, to determine relative amounts of time devoted to different daily activities. Breeding Mallards spent most of their time at one or two locations within their territories. During incubation, pairs appeared to avoid open areas. Data are presented showing relative amounts of time spent by males and females foraging, resting, loafing and alert, preening and bathing, and in aggression. Females spent more time foraging than males before and during nesting. Males must spend time alert and in aggressive activity to protect their reproductive investment, thus time spent foraging, and their body weights tend to decrease while they are territorial. Although females can rely to a large extent upon endogenous energy stores, I believe that they must still forage to complete incubation successfully.

Key Words: Mallard, *Anas platyrhynchos*; behavior, habitat utilization, pothole habitat, Manitoba.

In the last decade, one approach to the study of behavioral ecology has involved the compilation of time–activity budgets. Recent publications reporting time–activity budgets for birds have included those for breeding Gadwalls (*Anas strepera*), Northern Shovelers (*A. clypeata*), Black Ducks (*A. rubripes*), Northern Pintails (*A. acuta*), and Blue-winged Teals (*A. discors*) (Dwyer 1975; Poston 1974; Afton 1979; Wooley and Owen 1978; Seymour and Titman 1978; Hickey 1980; Derrickson 1977; Miller 1976; Stewart and Titman 1980). Dwyer (1975) and Owen (Wooley and Owen 1978; Owen and Reinecke 1979) translated time–activity budgets into energy budgets, and Afton (1979) considered behavioral strategies for optimum use of environmental resources. Time–activity budgets help in understanding habitat utilization and niche occupation by animal species. The aim of this study was to determine the time allocated to different daily activities by breeding Mallards (*Anas platyrhynchos*). Because the female assumes sole responsibility for the nest and appears to invest more energy than the male in reproduction, it was hypothesized that the time–activity budgets of paired males and females are different.

Study Area

The study area consisted of two 260-ha plots, with 104 and 158 potholes, respectively, amid agricultural fields in southwestern Manitoba (50°10′N, 99°45′W), about 30 km north of Brandon. The geological history, topography, soils, climate, and plant communities of the Minnedosa region were described by Evans et al. (1952) and the local history, habitat conditions, and waterfowl population trends by Kiel et al. (1972). The ponds in the region ranged from less than 0.04 ha to about 5.0 ha in area and from 8 cm to 2.5 m in depth. About 52% were less than 0.2 ha in area. The interspersion of agricultural land, cover, roads, and water in the area where one pair was followed in 1971 is shown in Figure 1.

Methods

Data were obtained from observations of 14 marked Mallards between early April and mid-July in 1970 and 1971. Both members of four pairs were marked, the females only of four pairs, and only the males in two pairs. Most of the information concerns the members of one pair (both marked) which were observed for over 155 h (Table 1). Collectively the nine other pairs were observed for about 67 h.

Observations were conducted from first light until after dark in periods lasting from 30 min to 5 h. Activity was recorded continuously instead of being sampled at timed intervals (Altmann 1974). Periods of observation totalling 6–8 h daily, 6 d/wk, were staggered to permit observation during each daylight hour at least once a week. Observations aided by 7× binoculars and 20 to 45× telescope were made at varying distances from a tower, blinds, or an automobile. In some cases where vision was obstructed by vegetation, the birds' location was known (e.g., Table 2), although behavior could not be recorded. Hens were not seen as they laid or incubated eggs. Activities were timed using a watch and stopwatch, and notes were recorded on tape. Movements were recorded on maps. Mallards were captured using nest traps and

TABLE 1—Distribution of observation time (min) for one marked pair of Mallards — Minnedosa, Manitoba, 1971

Central Standard Time	First laying 19 April - 13 May	Incubation 14–22 May	Renesting interval 23–29 May	Second laying 30 May - 5 June	Incubation 6–15 June	Renesting interval 16–24 June	Third laying 25 June - 1 July
04:25–08:00	350	895	250	480	324	132	158
08:01–11:00	170	90	270	160	340	475	261
11:01–15:00	30	30	235	350	235	259	278
15:01–18:00	285	155	210	340	281	160	10
18:01–21:08	295	618	379	330	380	110	101
Totals	1130	1788	1344	1660	1560	1136	808

cannon nets (Giles 1969) and individually marked with numbered plastic nasal saddles (Bartonek and Dane 1964).

Activities were classified into the following categories:

Preening — bathing — all behavior associated with external body maintenance and comfort (= "care of the body surface and related activities" of McKinney 1975).
Foraging — all behavior associated with search for food, capturing it, and manipulating or ingesting it, either on land or in the water.
Aggression — this ranged from simple threat and avoidance to energetically costly chasing in pursuit flights (McKinney 1965).
Resting — birds in repose held their heads down on their shoulders, either sleeping with eyes closed and bill tucked into scapular feathers or awake yet lethargic.
Loafing — Alert — Loafing birds might either be walking, swimming, or stationary. They held their heads upright and were active and fully aware of their surroundings but not performing any of the above activities. Alert birds usually held their heads further upstretched and watched or listened for potential intruders, predators, or disturbance (Dwyer 1975).

Results

Location of Activity

Only two pairs sighted more than 75 times provided sufficient information to describe the location of activity within their range. The male of pair A spent 70% of his time on or within 60 m of one pond (about 2.0 ha) in his territory (Figure 1). During the time that the male behaved territorially, his mate was with him 48% of the time (Table 2). She spent most of the remainder at her nest. The other pair, which was observed for 846 min, spent 66% of its time on or within 50 m of two ponds within its territory. These results support Hochbaum's (1944) observation that breeding dabbling duck pairs concentrate their activity at one or two locations.

Pair A was kept under observation from 19 April to 8 July 1971, during which time the female made three nest attempts. Beginning 5 May, she laid nine eggs. After 8 d of incubation, the nest was destroyed by a mammalian predator on 22 May. Eight eggs were laid in a second nest that was initiated 8 d later. This was destroyed after 8 d of incubation during the night of 15 June. Although it was not located, a third nest probably was initiated on 23 June, and incubation continued until 8 July when the female was last seen.

Pair A spent more time in cover and less time in the open after the female had started to incubate, particularly after beginning to incubate her second nest later in the breeding season.

Time Allocation

The relative amounts of time spent by male and female Mallards performing different activities at different times throughout the day are summarized in Figure 2. Both sexes tended to be more active (i.e., not resting, loafing, or alert) during the later daylight hours. This illustration does, however, mask the well-known momentary peaks in activity around sunrise and sunset (Winner 1972).

Time spent flying was not plotted in the histograms (Figures 2 and 3) because it was difficult to measure, especially when birds were lost from sight, and because it constituted a small proportion of total activity. It is nonetheless important because of its high energetic cost and should receive more careful consideration in future studies.

Overall, females spent significantly more time foraging than their mates ($P < 0.01$) as illustrated in Figures 2 and 3. Although intensity was not measured directly as Seymour and Titman (1978) did, it appeared obvious from observation that females fed at a greater rate.

Foraging was the predominant activity of female A during recesses while she was incubating (Figure 3). She also spent a lot of time preening and bathing

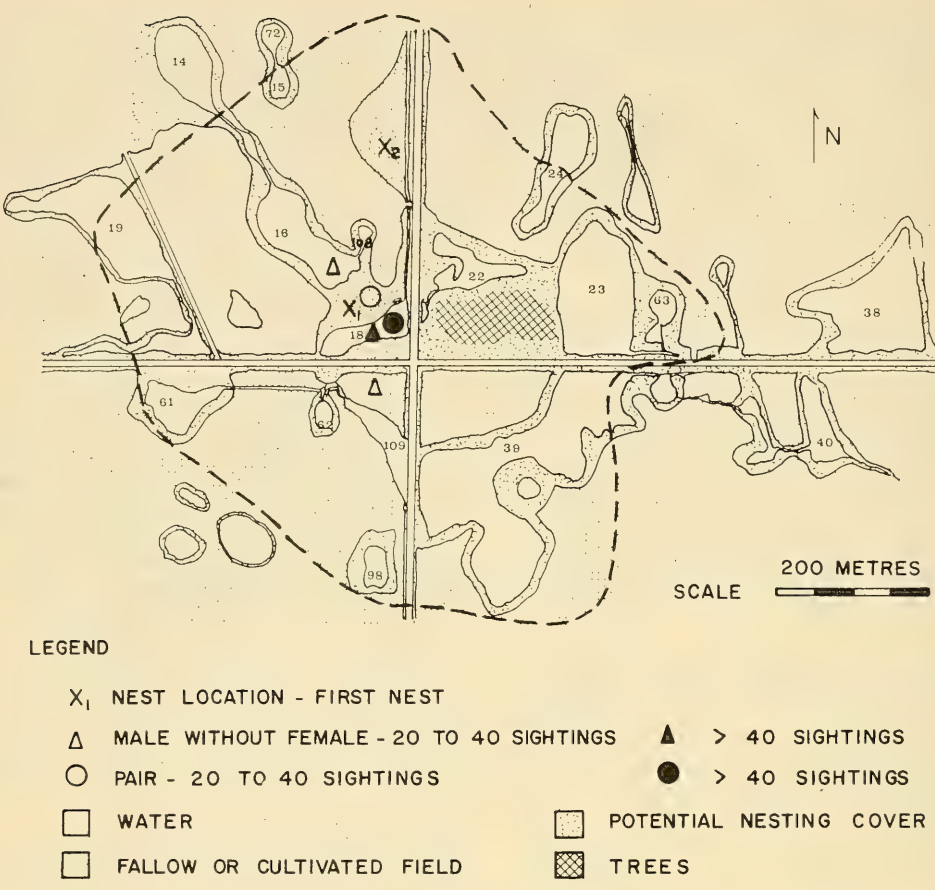

FIGURE 1. Area of activity of pair A from 19 April to 8 July 1971, near Minnedosa, Manitoba. Cultivated fields east and south of the crossroads were seeded in grain crops (wheat, barley). In the northwest segment the field immediately west of pond 16 was seeded with alfalfa while the one northeast was left in stubble from the previous year's wheat.

TABLE 2—Percentages of time spent by male A on various parts of his home range (see Figure 1) during daylight hours and time spent with his mate and with other males during the breeding season

Period	Pond 18	Fields near pond 18	Fields near ponds 62 and 109	Pond 108	Pond 22	Elsewhere	Total min under observation	% time with female A	% time with other males
Laying 1st clutch	58.6	8.8	7.9	0.3	0.8	23.6	1130	70.3	0.5
Incubation	52.8	8.0	10.3	4.3	1.6	23.0	1808	22.6	20.8
Renesting interval	58.3	21.0	2.6	3.1	3.2	11.8	1564	81.0	2.6
Laying 2nd clutch	62.2	23.8	3.1	0.4	4.6	5.9	1438	70.1	16.8
Incubation	25.7	28.1	2.5	22.2	0	21.5	1380	2.7	51.4
Renesting interval	15.5	45.3	4.1	21.9	13.1	0.1	1134	83.7	4.6
Laying 3rd clutch	30.8	62.1	0	1.8	5.3	0	768	23.0	6.9
Overall (total or mean)	45.5	24.7	4.8	7.6	3.7	13.7	9222	48.3	16.0

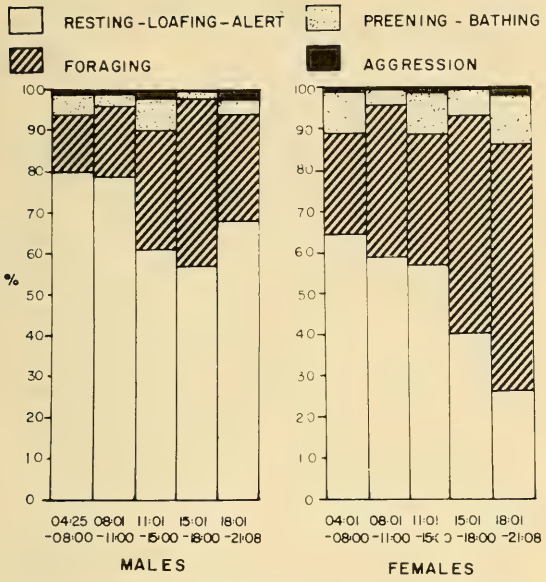

FIGURE 2. Histograms showing activity of all marked male and female Mallards during daylight hours in the breeding seasons of 1970 and 1971, Minnedosa, Manitoba. Only time spent off the nest (by the female) is shown.

during these incubation recesses, as Sowls (1955: 103) observed, yet contrary to his impression, feeding assumed primary importance. Her whole daily energetic requirement had to be satisfied within a period Caldwell and Cornwell (1975) found to last an average of 78 min.

Meanwhile, her mate spent less time foraging and more time loafing or alert, particularly while female A was with him, which would allow their quick response to the approach of an intruder (Figure 3). Male A spent proportionally more time being aggressive to intruders on their territory while his mate was laying her first clutch. Later in the season, during the absence of his mate at her nest, male A spent an increasing proportion of his time with other males (Table 2). In general, males tended to be gregarious when they left their mates that were caring for nests and young.

Discussion

There were significant differences between the time-activity budgets of paired male and female Mallards. These differences were principally in the greater time spent foraging by females to meet the high caloric cost of egg production. Others have recorded similar differences between breeding male and female Gadwalls, Northern Shovelers, Blue-winged Teals, Black Ducks, and Harlequin Ducks (*Histrionicus histrioni-*

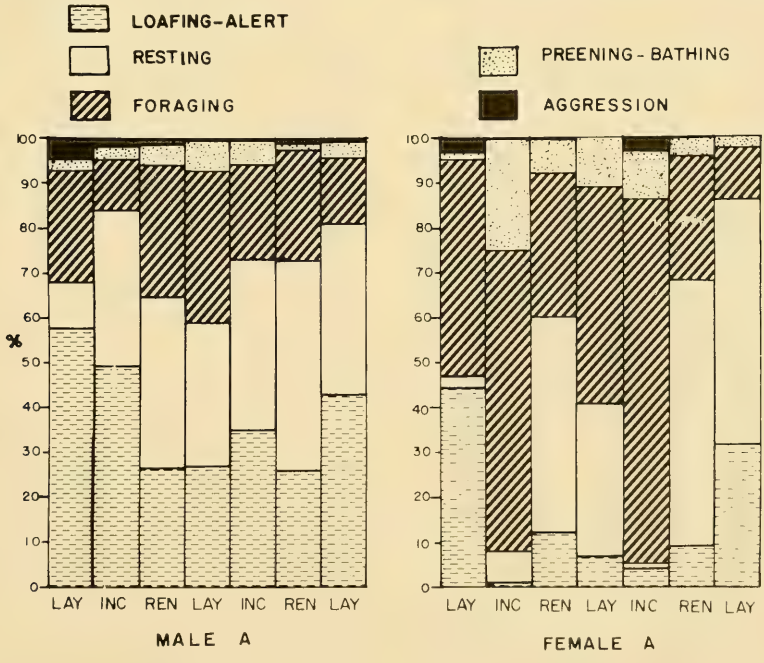

FIGURE 3. Histograms showing activity of pair A for seven periods through the breeding seasons, 1971. Only time off the nest (by the female) is shown.

cus) (Dwyer 1975; Poston 1974; Afton 1979; Miller 1976; Stewart and Titman 1980; Seymour and Titman 1978; Bengtson 1972).

Weight losses from the beginning to the end of the breeding season indicated a decline in energy stores over this period by both females and males (Folk et al. 1966; Young 1977). During the breeding season, Mallards do not spend sufficient time feeding to secure the energy to balance their daily energy budgets. This phenomenon is known in Ross's Geese (*Anser rossii*), Lesser Snow Geese (*A. caerulescens*), Canada Geese (*Branta canadensis*), and Common Eiders (*Somateria mollissima*); however, these large species can rely to a greater extent upon endogenous reserves (Ryder 1970; Ankney 1977; Ankney and MacInnes 1978; Raveling 1979; Milne 1976).

Eggs are costly for females to produce and then incubate. Incubation may be no more costly than normal daily activity, but it involves a time investment precluding foraging. Afton (1979) argued that Northern Shovelers have to forage during incubation to survive and successfully produce young. Using my data (Titman 1973) and those of Caldwell and Cornwell (1975), Afton calculated that Mallard females feed for about 23 h during the 26-d incubation period whereas Shovelers feed for 58 h over a 23-d incubation period. Although the Mallard is larger and may rely more upon endogenous reserves, it must still forage to obtain sufficient energy and nutrients to survive. In contrast, female geese and eiders may not feed at all during incubation, and some die in the process (Ryder 1970; Ankney and MacInnes 1978; Raveling 1979; Korschgen 1977).

A major role of the male is to ensure that his mate can feed undisturbed while off her nest. This is accomplished in different ways by different species. Shovelers defend exclusive territories (Seymour 1974), whereas a Mallard territory is not as well defined, but the female is defended from intruders (Titman 1973). The male Northern Shoveler defends a territory until 2 d before hatching when the female is more attentive to her nest and spends less time off it. Male Mallards usually abandon their incubating mates about one-half way through incubation. The timing may have evolved to ensure protection of the female to a point when she could complete incubation and survive on her reserves alone.

Males spent a lot of time loafing and alert instead of feeding, especially during laying and incubation by their mates. For Gadwalls, Dwyer (1975) recorded that males spent highest proportions of time alert just before and during laying. I believe that a male Mallard must spend time alert as well as in aggression to protect his reproductive investment. This prevents him from devoting sufficient time foraging to maintain body weight (Folk et al. 1966; Young 1977). This prediction can be tested by monitoring physiological condition and by compiling detailed time-activity budgets for breeding males.

Acknowledgments

I am grateful to H. A. Hochbaum, former director of the Delta Waterfowl Research Station, and the late Bruce S. Wright, former director of the Northeastern Wildlife Station, for their advice and encouragement. Robert O. Bailey gave field assistance and Hugh Boyd, Frank McKinney, Alex Dzubin, and Norman Seymour generously offered their comments and criticisms during my study. I am grateful to L. Fredrickson, J. B. Gollop, and J. P. Ryder for critical review of different drafts. Funds were granted by the North American Wildlife Foundation through the Delta Waterfowl Research Station and by the Department of Biology and Faculty of Graduate Studies and Research at the University of New Brunswick.

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First submission received 10 June 1975
Revision received 30 July 1980
Accepted 10 February 1981

Invasion of a New Reservoir by Fishes: Species Composition, Growth, and Condition

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After the first summer of inundation, the ichthyofauna of the reservoir known as Guelph Lake was compared to that of the Speed River before impoundment. Several species that had been rare in the river showed marked increases in relative abundance in the reservoir. The Bluntnose Minnow (*Pimephales notatus*) was most abundant among 19 species collected. For young-of-the-year of three species, Bluntnose Minnow, Common Shiner (*Notropis cornutus*), and Creek Chub (*Semotilus atromaculatus*), which were abundant enough for comparison, growth was faster in the reservoir than in the river. For these species and White Sucker (*Catostomus commersoni*), the average condition (weight at a given length) was significantly higher in the reservoir.

Key Words: impoundment, colonization, reproduction, abundance, river.

Although the construction of reservoirs for flood control and low flow pollution abatement are common practice in southern Ontario, there are few studies of the biology of fishes in such reservoirs, or of the effects of these impoundments on their rivers. In 1975, Mahon et al. (1979) studied the distribution and productivity of fishes in the Speed River, Ontario, to provide a background for assessment of the development of the ichthyofauna in the impending reservoir (Guelph Lake) and its impact on the river.

In spring 1976 the reservoir was filled. It covers an area of about 400 ha with the midpoint located at 43°37′N, 80°15′W, its maximum depth is about 12 m (D. Tregunna and K. Walker, Landscape Architecture, University of Guelph, 1974, unpublished data). The purpose of our study was to record the species of fishes that had invaded the inshore regions of the reservoir by the fall of 1976, and to compare the species composition and where possible the growth and condition of the fishes with those in the Speed River before impoundment.

Methods

A seine (10 × 0.9 m with 6-mm circular mesh) was used to collect fishes from 18 localities throughout the main body of the reservoir (Figure 1) on 12 and 18 September 1976. After identification, three species for which there were enough individuals for growth to be compared were measured (SL) to the nearest 1 mm and weighed to the nearest 0.1 g. For Common Shiner (for scientific names see Table 1) and Creek Chub, all individuals were measured; for Bluntnose Minnow, a subsample of 559 individuals was taken by mixing all the fish in a tray and separating off about one quarter of the sample. In each case there was a distinct mode of small fish in the length–frequency histogram. Previous experience has shown that for these species this mode is a reliable indicator of age (Mahon and Balon 1977b; Mahon et al. 1979). Growth was compared for these young-of-the-year.

For the above three species and for White Sucker, condition of individuals of all sizes was compared to that of individuals of the same species in the Speed River in 1975. This was done by comparing the observed weight at a given length (W_{ob}) with the expected weight for a fish of that length before impoundment as predicted from weight–length equations given by Mahon et al. (1979). The ratio of observed to expected weight indicates whether the fish is heavier or lighter than average for its length, with heavier fish being in better condition. An average ratio of one would indicate no difference in condition. Direct comparison of growth and condition between the reservoir and the river is possible because the Speed River localities were sampled a year earlier on 14 and 17 September 1975.

Results

The land inundated by the reservoir was primarily agricultural with scattered woods which were cleared before filling. Therefore the fishes were collected from a variety of substrate types: submerged grasses, corn stubble, cleared woodlot, mudflat, and old river floodplain. In contrast the Speed River is a typically fast-flowing, warmwater (non-trout) stream with a gravel, cobble, and rubble substrate. Some lateral pools and backwaters did, however, provide habitat for more lentic species (Mahon et al. 1979).

Altogether, 4130 fishes comprising 19 species were collected from the reservoir at the end of the first summer after filling. The relative abundance of these species is shown in Table 1. The fish community was

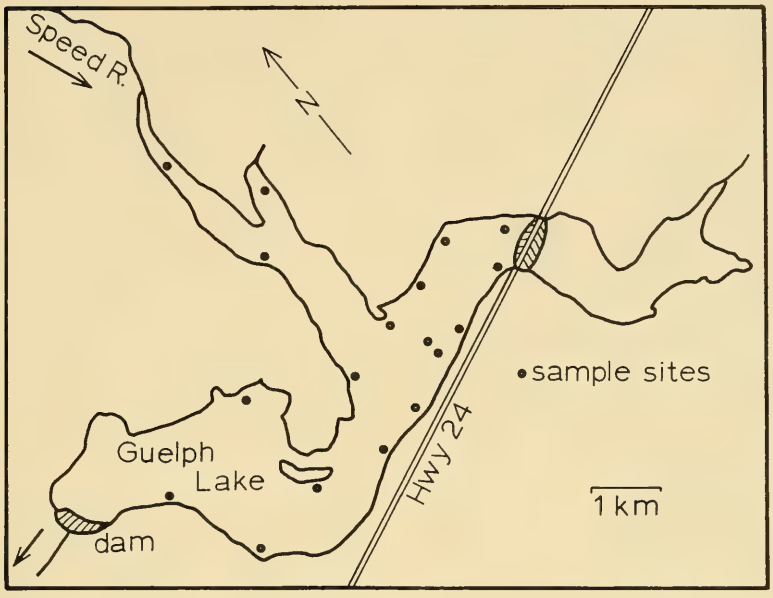

FIGURE 1. Guelph Lake with sampling locations shown. For the exact location of the reservoir, refer to Figure 1, Mahon et al. (1979).

clearly dominated by the Bluntnose Minnow. Most of the fishes collected were young-of-the-year.

In Table 2, the mean standard length for young-of-the-year of three species is compared between the reservoir and three localities combined in the Speed River. These localities were a few kilometers above, within, and just below the reservoir (QN2, QN4, and QN5, respectively, Mahon et al. 1979). For each species growth was faster in the reservoir than in the river.

For fishes of the above three species and the White Sucker, the mean condition of individuals in the reservoir for each species was significantly greater than one (t-test, $P < 0.05$) (Table 3). In no case was there any tendency for condition to be correlated with size.

Discussion

Of the 18 species of fishes collected from the upper Speed River watershed in 1975 (Mahon et al. 1979), 14 were collected in this study. The remaining five species collected from the reservoir have been reported from the Speed River watershed, but Carp and Brown Bullhead only from below the city of Guelph wherein there are several weirs and dams that would be expected to restrict the upstream movement of these species. Therefore, we did not expect to find them in the reservoir.

There is considerable overlap between the species lists for the reservoir and the river, but the differences in relative abundance are marked. Table 1 shows the relative abundance of the 14 species of fishes collected in the Speed River in the immediate vicinity of the reservoir a year before impoundment. In the river, the Fantail Darter, Creek Chub, and Northern Hogsucker were dominant, whereas in the reservoir, Bluntnose Minnow and Common Shiner were most abundant. The dominance of the Bluntnose Minnow young-of-the-year probably reflects their reproductive strategy which is to guard a brood of eggs attached to the underside of a log, stone, or similar object. Amongst those fishes that were common in the river, only the Bluntnose Minnow would be expected to reproduce equally well in the reservoir. Brook Stickleback, Bluntnose Minnow, and Fathead Minnow were the dominant species in two temporary streams in southern Ontario (Williams and Coad 1979); this suggests that they tend to invade newly created habitats rapidly. In addition these three are not strict 'stream species' and are common in shallow bog lakes and ponds. Although lacustrine populations of Creek Chub and Common Shiner do occur, they usually require flowing water for spawning (Scott and Crossman 1973). Shoal-spawning is a possibility provided there is silt-free gravel or rubble, thus providing conditions which are similar to those in a stream (Kitchell et al. 1977); such conditions are rare in Guelph Lake. For similar reasons neither the Smallmouth Bass nor the Rock Bass are likely to colonize this reservoir.

TABLE 1—The relative abundance (percentage) of fishes in Guelph Lake, 1976, and in the Speed River in the vicinity of the reservoir before impoundment (Mahon et al. 1979)

Species	Guelph Lake	Speed River
Bluntnose Minnow (*Pimephales notatus*)	60.7	4.2
Common Shiner (*Notropis cornutus*)	13.6	5.6
Pumpkinseed (*Lepomis gibbosus*)	8.6	0.1
Fathead Minnow[a] (*Pimephales promelas*)	6.0	—
Brook Stickleback (*Culaea inconstans*)	3.4	0.1
Redbelly Dace[a] (*Chrosomus eos*)	2.3	—
Brassy Minnow[a] (*Hybognathus hankinsoni*)	2.0	—
Creek Chub (*Semotilus atromaculatus*)	1.8	16.3
White Sucker (*Catostomus commersoni*)	0.5	2.8
Carp[b] (*Cyprinus carpio*)	0.3	—
Johnny Darter[b] (*Etheostoma nigrum*)	0.3	—
Rosyface Shiner[c] (*Notropis rubellus*)	0.2	—
Fantail Darter (*Etheostoma flabellare*)	0.1	51.2
Northern Hogsucker (*Hypentelium nigricans*)	0.1	13.3
Brown Bullhead[b] (*Ictalurus nebulosus*)	0.1	—
Pearl Dace[d] (*Semotilus margarita*)	0.1	—
Blacknose Dace (*Rhinichthys atratulus*)	0.1	0.2
Rock Bass (*Ambloplites rupestris*)	0.1	1.3
Mottled Sculpin (*Cottus bairdi*)	0.1	0.1
Smallmouth Bass (*Micropterus dolomieui*)	—	3.9
Longnose Dace (*Rhinichthys cataractae*)	—	0.9
Mudminnow (*Umbra limi*)	—	0.2
Total number of fishes collected	4130	1897
Total number of species	19	14

[a]Occurs in the Speed River above the dam.
[b]Occurs in the Speed River below the dam.
[c]Previously collected only from the Eramosa River, a tributary which enters the Speed River, below the dam, in Guelph.
[c]Collected from the Speed River in 1951 but not found in 1976.

TABLE 2—Comparison of mean standard length (SL) of young-of-the-year between Guelph Lake and three localities (combined) in the Speed River before impoundment

	Guelph Lake		Speed River	
Species	SL±SD	(*n*)	SL	(*n*)
Common Shiner	36.4±3.63	(224)	29.4	(387)
Creek Chub	54.7–6.30	(44)	40.9	(579)
Bluntnose Minnow	33.3±5.74	(515)	27.6	(1234)

TABLE 3—Mean condition of individuals of four species in Guelph Lake, based on weight–length relationships for these species in the river before impoundment

Species	Mean condition±SD	(*n*)
Common Shiner	1.32±0.099	(84)
White Sucker	1.28±0.266	(22)
Bluntnose Minnow	1.13±0.177	(78)
Creek Chub	1.13±0.113	(65)

Those species that should successfully colonize a reservoir are usually rare in fast-flowing rivers. However, this study illustrates that the small populations inhabiting backwaters and lateral pools are sufficient for widespread and rapid colonization. Pumpkinseed, Brook Stickleback, Redbelly Dace, and Fathead Minnow though rare in the river became common in the reservoir in just a few months (Table 1). The species composition in a vegetated lateral pool in 1975 was similar to that in the reservoir at the end of the first summer. The Mudminnow provides an exception. Dominant in vegetated lagoons on the shore of Lake Erie (Mahon and Balon 1977a) and abundant in the above-mentioned pool, this species was not found in the reservoir. The Mudminnow spawns in early spring before the snow melts. At that time the reservoir was not sufficiently filled for much new suitable habitat to have been created.

Growth and condition of those fishes for which comparison was possible was better in the reservoir than in the river (Tables 2 and 3). Gasaway (1970) also found increased growth in a new reservoir but this was

a temporary effect. Increased growth and better condition could result from higher temperature in the reservoir and/or from increased food abundance, provided that food was limiting in the river. Unfortunately, we are unable to separate the effects of these factors and thereby evaluate the hypothesis that stream fish populations are commonly limited by density-independent rather than density-dependent factors. We are able, however, to eliminate the possibility that the difference arose through differences in temperature between years. Monthly mean maximum and minimum air temperatures for the 1975 and 1976 growing seasons (April–October) at a station about 20 km from the reservoir were similar (Figure 2). If any difference between the years exists it is towards higher temperatures in 1975, this would tend to emphasize the differences between the fish in the reservoir and the river.

This study shows characteristic shifts in species composition and growth after impoundment (Jackson and Rogers 1976). Notable is the speed with which many species, originally rare in the river, were able to invade the newly created habitat. There was no marked reduction in the number of species as is considered normal, possibly because of the presence of leftover riverine species not yet eliminated by the changed conditions and the explosive expansion of those species better suited to the reservoir. In a permanent reservoir, this would most likely be a temporary phenomenon associated with filling (June 1976). Guelph Lake, however, is a typical flood control reservoir, drawn down every fall and refilled every spring during the thaw. The extent and timing of the drawdown depends on the amount of water required during the summer for low flow augmentation. Under these conditions the reservoir fauna would not be expected to exhibit the successional sequence typical of a more stable reservoir constructed, for example, for hydroelectric power generation. Instead the reservoir may be characterized year after year by a fish community similar to that observed in this study.

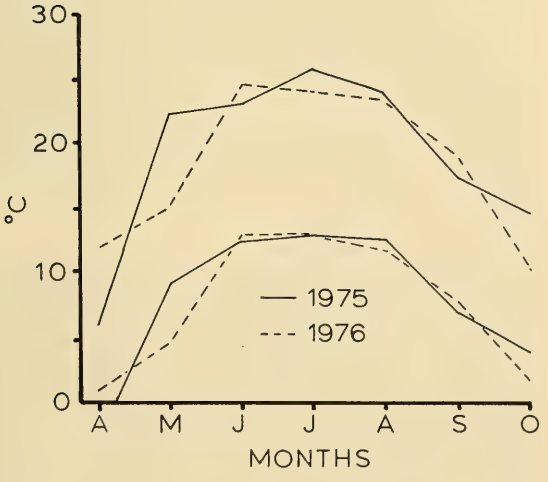

FIGURE 2. Mean monthly maximum and minimum air temperatures during the 1975 and 1976 growing seasons (data supplied by Department of Land Resource Sciences, University of Guelph).

Acknowledgments

We thank Susan Mahon, who helped with the field work and criticized the manuscript. Thanks also to the Experience '76 Program, Ontario, for financial assistance during the sampling. The comments of an anonymous referee served to improve the manuscript greatly. This project was supported by a Natural Sciences and Engineering Research Council operating grant to Eugene Balon.

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Received 10 May 1980
Accepted 14 November 1980

Distribution and Harvest of Canada Geese (*Branta canadensis*) in Southern Manitoba Prior to Development of Oak Hammock Marsh

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Raveling, Dennis G., and Charles C. Dixon. 1981. Distribution and harvest of Canada Geese (*Branta canadensis*) in southern Manitoba prior to development of Oak Hammock Marsh. Canadian Field-Naturalist 95(3): 276–280.

The numbers, distribution, and harvest of different subspecies of Canada Geese (*Branta canadensis*) in autumn in southern Manitoba were studied between 1967 and 1970 prior to the restoration of Oak Hammock Marsh near Winnipeg. Small numbers of Canada Geese were found in many locations, but only about a dozen sites were used by 1000+ birds. Peak populations in southern Manitoba varied from about 15 000 to 30 000 Canada Geese. The Interlake region between Lakes Manitoba and Winnipeg contained the most geese and was the site of an estimated 45% of the kill by hunters. Giant Canada Geese (*B. c. maxima*) predominated in the harvest in most of the Interlake, in southeast and west-central Manitoba. *Branta c. interior* and a similar goose were the major forms killed in the southern Interlake near where the redeveloped Oak Hammock Marsh now attracts autumn peak populations of up to 120 000 migrant Canada Geese. Small Canada Geese (*B. c. hutchinsii* and similar forms) predominated in the kill on the Red River, at Delta, and in southwest Manitoba.

Key Words: *Branta canadensis*, Canada Goose; distribution, numbers, hunter kill, subspecies.

Canada Goose (*Branta canadensis*) occupies a broad geographic range, from the west to the east coast and from the arctic islands to the prairies (Delacour 1954), and is highly variable in morphology. Proper understanding and management of Canada Geese depends on increasing knowledge of the interrelationships of different subspecies and populations. The resident breeding Canada Geese in southern Manitoba are the large and relatively pale-colored *B. c. maxima* (Hanson 1965; Raveling 1976, 1978). The dominant form in northern Manitoba is the smaller and darker *B. c. interior* which nests primarily on the Hudson Bay Lowlands (Hanson and Smith 1950; Vaught and Arthur 1965; Malecki et al. 1980), but some also nest on the Canadian Shield in the interior (Raveling 1977). They stop during migration in southern Manitoba as do small Canada Geese (*B. c. parvipes–hutchinsii* complex of MacInnes 1966), which nest on the tundra adjacent to, and on the islands of, Hudson Bay and along the arctic coast.

Habitat loss or restoration may have pronounced effects on the distribution of migratory birds and, for game species, these changes may greatly alter the impact of hunters on populations. Oak Hammock marsh is a 3360-ha managed wetland 23 km north of Winnipeg, Manitoba. The area was acquired between 1967 and 1972 and developed to desired water levels by 1974 (Oetting and Dixon 1975). A major effect of Oak Hammock has been a change in distribution and numbers of geese in southern Manitoba during their autumn migration. Annual concentrations of Canada Geese have averaged 80 000 between 1974 and 1979 in the Oak Hammock area.

In anticipation of an expanded program of goose management and harvest in Manitoba, the Canadian Wildlife Service (CWS) initiated a study in 1967 in cooperation with the provincial Department of Natural Resources (DNR) to determine the status and distribution of Canada Geese in southern Manitoba. The purpose of this paper is to present data on the occurrence of Canada Geese in autumn in southern Manitoba and on the relative importance of different subspecies to hunters in different geographic areas during the late 1960s. These data also form a baseline with which to compare subsequent results brought about by changing population numbers, migration patterns, and habitat.

Methods and Materials

Weekly aerial inventories of goose numbers were conducted, weather permitting, in areas A, B, D, and F (Figure 1) by the CWS and in areas E and G by the DNR between mid-September and early November 1967–1970. Aerial searches in area C were irregular and supplemented with counts made by agency personnel on the ground. Specific locations visited regularly are indicated on Figure 1. Although we recognize that Canada geese occurred over a broader range, these locations were generally acknowledged to be of most importance during migration.

The distribution of harvest of Canada Geese was indicated by the return of goose tail feathers by hun-

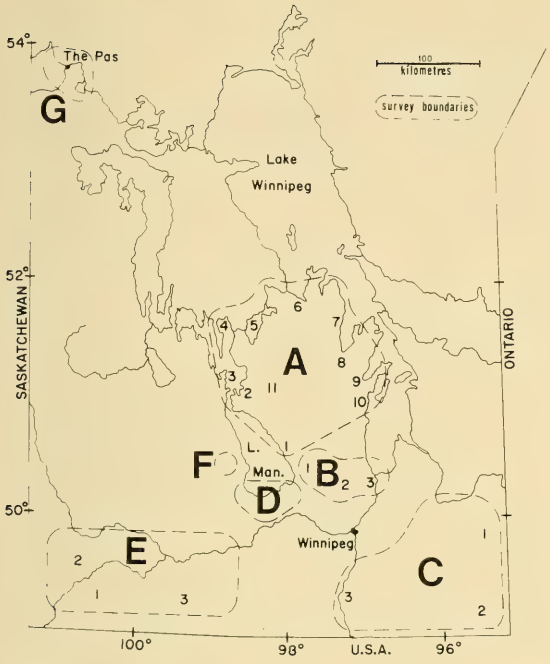

FIGURE 1. Locations of autumn aerial inventories and harvest of Canada Geese in southern Manitoba. Area A —1. Marshy Point Goose Sanctuary, 2. Dog-Moosehorn Lakes, 3. Reykjavik Point, 4. Peonan Point – Portage Bay, 5. Pinemuta Lake – Lake St. Martin, 6. Sturgeon Bay, 7. Saint Lakes, 8. Fisher Bay, 9. Washow Bay, 10. Hecla Island – Riverton Marshes, 11. Sleeve Lake. Area B — 1. Shoal Lakes, 2. Oak Hammock, 3. Netley–Libau Marshes. Area C — 1. Alf Hole Goose Sanctuary, 2. Whitemouth Lake, 3. Red River. Area D — Delta Marshes. Area E — 1. Whitewater Lake, 2. Oak–Plum Lakes, 3. Pembina Valley Lakes. Area F — Big Grass Marsh. Area G — The Pas vicinity: Kelsey, Little Kelsey, Niska, Helldiver, Cul de Sac, Mawdesely, Cumberland Lakes.

ters cooperating in the CWS parts collection survey (Canadian Wildlife Service 1968). The raw data were provided by G. Cooch (CWS) so we could proportion the harvest to our areas of interest which differed from the zones used by CWS.

Determinations of the subspecies of Canada Goose killed by hunters were made by the authors. Some hunters were contacted in the field, and the bag of some others was examined at check stations periodically established along major road systems by the DNR. Most specimens were, however, saved for us by a group of cooperative sportsmen who were contacted personally and who were provided with plastic bags, tags, and detailed diagrammatic instructions for saving parts from each goose that they or their friends had killed. Parts saved from each goose were head and neck including the feathering below the black neck, a wing, a leg (below the feathers), and tail feathers, preferably cut off above the pygostyle so that the entire tail "fan" was preserved and measurements could be compared to those available from live and museum specimens.

Measurements of these parts were compared to those available in the published literature and records available from trapped geese from different populations and museum specimens. Paramount among these sources were Hanson (1951, 1965), MacInnes (1966), and Raveling (1976, 1977). Some hunters knew how to identify sex of geese and provided us with that information, but most did not. As adult males of one race may overlap in size with females or immatures of a larger size race, discrimination of subspecies depended on personal experience and knowledge of color and proportions as well as obvious measurements such as culmen, tarsus, toe, wing, and tail lengths.

Results and Discussion

Distribution and Numbers of Canada Geese

Small numbers of Canada geese occurred in many areas in autumn, but few locations attracted over 1000 birds. Marshy Point (area A1, Figure 1) regularly held 2000–4500 geese during autumn. Other locations where a peak of over 1000 (but less than 2500) Canada Geese were seen on at least one occasion were (see Figure 1 for locations indicated by letter-numeral) Dog–Moosehorn Lakes (A2), Peonan Point – Portage Bay of Lake Manitoba (A4), Washow Bay in Lake Winnipeg (A9), Hecla Island – Riverton Marshes in Lake Winnipeg (A10), Sleeve Lake (A11), Shoal Lakes (B1), Alf Hole Goose Sanctuary (C1), Delta Marsh shoreline of Lake Manitoba (D), Whitewater Lake (E1), Swan Lake in the Pembina Valley (E3), Big Grass Marsh (F), and Kelsey and Little Kelsey lakes near The Pas (G).

In general, no area attracted a major concentration of Canada Geese (Table 1) relative to many other places in North America. Most Canada Geese in areas A, C, and G were giant Canada Geese that nested in the vicinity (see Raveling 1976, 1978, and below). Based on knowledge of the size and migration patterns of other populations of Canada Geese killed in Manitoba (MacInnes 1966; Vaught and Kirsch 1966), it is obvious that several 100 000 migrants passed over southern Manitoba and those that stopped did so for short periods, in many areas, and in relatively small numbers. Regular aerial inventories did not always coincide with transitory peak populations; therefore,

TABLE 1—Peak numbers of Canada Geese observed in southern Manitoba during autumn aerial inventories, 1967–1970

Area (see Figure 1)	Peak numbers of Canada Geese
A	6 400–14 100
B	1 400–4 900
C	1 300–3 100
D	700–1 700
E	800–3 200
F	600–2 500
G	2 300–3 000
Totals (peaks in a given year)[a]	15 400–29 900

[a]Totals differ from sum of columns because peak numbers in different areas did not occur in the same year.

estimates in Table 1 are minimal. For example, an estimate (from the ground) of 9500 Canada Geese was made at West Shoal Lake 3 d after an aerial inventory had revealed 2300. Despite these problems, Table 1 reveals the general diffuse nature of Canada Goose distribution in southern Manitoba in the late 1960s. Geese stopping during days of major migration movements did not stay for more than a few hours or days.

Distribution of Harvest

The widespread distribution of Canada Geese shown by aerial inventories was also reflected by the variety of locations from which hunters reported killing birds from which they sent in tail feathers (Table 2). About 20% of the kill occurred in locations where inventories had not been taken. In total, however, the Interlake region between Lakes Manitoba and Winnipeg was the most important area of harvest of Canada Geese with about 45% of the reported kill (areas A and B, Figure 1). This was divided approximately equally between the Shoal Lakes to Netley Marsh area (area B) and the remainder of the southern Interlake region (area A).

Subspecies Composition of Harvest

Small Canada Geese were of two types: those typical of McConnell River and Southampton Island, Northwest Territories, described by MacInnes (1966), and an even more diminutive form. For purposes of this report, they were combined. While most "middle-sized" Canada Geese were clearly *B. c. interior*, there was also a form slightly smaller (but distinctly larger than the "small" Canadas) in all measurements. This form was not obviously present in Wisconsin and Illinois samples reported by Hanson (1951, 1965) or Raveling (1977). It probably represents an undescribed subspecies. For this paper, they were combined with *B. c. interior* as middle-sized Canada Geese. The giant Canadas were *B. c. maxima* as described by Hanson (1965).

The type of Canada Goose killed by hunters varied greatly by geographic area and even between closely spaced locations within an area (Table 3). Small Canada geese predominated at Delta, Big Grass Marsh, in the southwest, and along the Red River (area C3). Their migration tended to be more irregular than that of the larger geese and their appearance in the harvest fluctuated accordingly in these areas (Table 2). Middle-sized Canada Geese were the major form killed in area B [primarily in the vicinity of West Shoal Lake, data came from 143 geese measured in 1965 and 1966 by L. Bidlake (1967 unpublished report of the Manitoba Wildlife Branch) and from 77 geese examined by the senior author in 1967]. Giant Canada Geese were most common in the harvest in areas A, C1, and G which also correspond to their main nesting areas (see Raveling 1976, 1978). The most even distribution of harvest of different forms of Canada geese occurred at Big Grass Marsh (area F) and Red River (C3).

Comparison of the distribution of geese (Table 1), and harvest (Table 2), with subspecies composition (Table 3) demonstrates the importance of local breeding giant Canada Geese in the Interlake to harvest by hunters in the late 1960s. This population was expanding rapidly (Gulden and Johnson 1968; Raveling 1978), but the kill was predominantly in Canada. Just a few kilometres away, middle-sized geese were the major component of the harvest in area B.

Since the establishment of Oak Hammock Marsh, large numbers of migrant geese of the Eastern Prairie

TABLE 2—Distribution of Canada Goose tail fans received from hunters by area in southern Manitoba[a]

		% in area (see Figure 1)							
Year	*N*	A	B	C	D	E	F	G	Other
1968	120	30.8	24.2	1.7	0.8	8.3	4.2	6.7	23.3
1969	246	15.0	20.3	5.3	8.9	16.7	5.7	1.6	26.4
1970	383	22.7	24.5	11.5	7.0	10.7	1.6	6.5	15.4
Totals	749	21.5	23.1	7.9	6.7	12.3	3.3	4.9	20.3

[a]Excludes tail fans for which no latitude/longitude coordinates were available and those from north of 54°.

TABLE 3—Types of Canada Geese in the hunter harvest by area in southern Manitoba, 1965–1971

Location[a]	No. examined	Percent		
		Giant[b]	Mid-size[b]	Small[b]
Area A[c]				
Marshy Point	100	67	30	3
Dog Lake	51	92	8	0
Fisher Branch – Hodgson – Sleeve Lake	89	53	36	11
Total area A	240	67.1	27.5	5.4
Area B[d]	220	1.8	80.5	17.7
Area C[c]				
Alf Hole	34	77	18	6
Red River	20	35	25	40
Total area C	54	61	20	19
Area D[c]	23	17	4	78
Area E[e]	27	4	11	85
Area F[c]	56	34	21	45
Area G[c]	92	72	28	0

[a]See Figure 1.
[b]See text.
[c]1968, 1969, and 1970.
[d]Almost all from West Shoal Lake in 1965, 1966, and 1967.
[e]Seventeen from Whitewater Lake, 8 from Pilot Mound, and 2 from Baldur.

Population (EPP) of *B. c. interior* have stopped in southern Manitoba during autumn. They traditionally stopped in spring when this area, as well as another location (Grants Lake vicinity) 19 km northwest of Winnipeg, were flooded by snow melt in early-mid April. Upwards of 70 000 geese were estimated to use these areas in spring 1969 and 1970, and their identity as EPP geese was established by observation of several geese neck-banded at Swan Lake, Missouri, the main wintering site for this population which nests in northern Manitoba (Vaught and Kirsch 1966). The restoration of Oak Hammock as a year-round marsh led immediately to its use in autumn by this population.

The varying proportions of different subspecies, and changes in numbers and distribution as habitat and population levels change, present problems and opportunities for management. The subspecies originate from totally different breeding habitats, and factors affecting their reproductive success and population size will vary independently. Therefore, surveys undertaken to assess age composition as reflected in the kill of geese by hunters must take into account the races involved. Regulations designed to meet goals established for one population might have entirely unintended effects on other populations. Knowledge of the location of geese of different origins presents the opportunity to be flexible in recommendations for harvest or habitat management specific to different populations. Sampling programs need to be continually reassessed as changes occur. Combining results just as Canada Geese, or just as large and small Canada Geese, can obscure recognition of the dynamics of these independent populations, of which small units may be particularly vulnerable to heavy harvest (cf. Raveling 1978).

Acknowledgments

We are grateful to numerous individuals who assisted in surveys, facilitated the collection of geese, or provided data from the national parts survey, especially L. Bidlake, E. Bossenmaier, D. Davies, R. Robertson, R. Urban, R. Webb, and many other regional staff of the DNR; G. Adams, G. Cooch, A. Dzubin, R. Halladay, and R. Hutchinson of CWS; H. A. Hochbaum and P. Ward of the Delta Waterfowl Research Station; L. King and the P. Curry and A. Vincent families of East Meadows Ranch at Clarkleigh; B. French and V. Jeffries of Rennie; R. Fortin of Clarkleigh; R. Otto and family of Ashern; C. Obszarski of Fisher Branch; S. Macks of Plumas; and numerous other sportsmen.

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Received 9 May 1980
Accepted 21 February 1981

Hill's Oak (*Quercus ellipsoidalis*) in Southern Ontario

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Ball, P. W. 1981. Hill's Oak (*Quercus ellipsoidalis*) in southern Ontario. Canadian Field-Naturalist 95(3): 281-286.

Hill's Oak (*Quercus ellipsoidalis*) is reported from several localities in southern Ontario near Galt and Brantford. This represents an eastward extension of the range of the species of over 200 km. In most localities in this area the trees occur in fence rows and hedgerows, and with the increasing urbanization and road widening that is occurring, many are in jeopardy. The distinction between *Q. ellipsoidalis, Q. coccinea* (Scarlet Oak), and *Q. velutina* (Black Oak) was made from leaf, bud, and acorn characteristics.

Key Words: *Quercus ellipsoidalis*, southern Ontario, distribution.

The occurrence of Hill's Oak (*Quercus ellipsoidalis*) in Canada in the Rainy River district of Ontario at the Northwestern edge of the range of the species has recently been reported by Maycock et al. (1980) (see Figure 1 for the known North American distribution). Hill's Oak was first recorded from Canada by Mitchell (1912) from Point Edward, Sarnia, Lambton County, Ontario. This record is supported by a specimen, formerly in the Dearness Herbarium, now in the herbarium of the Biosystematics Research Institute, Ottawa (DAO); it consists of some acorns and acorn cups and a few detached leaves. Whereas this material can be assigned to *Q. ellipsoidalis*, it could equally well be assigned to *Q. velutina* (Black Oak). A more complete specimen collected by Dodge and Tripp in 1915, which, according to a letter accompanying the DAO specimen, was from the same tree as that seen by Mitchell, is in the herbarium of the University of Michigan, Ann Arbor (MICH). As noted by Maycock et al. (1980) this specimen is undoubtedly *Q. velutina*, but the foliage is so different from the DAO specimen that it is doubtful if it did come from the same tree. Maycock et al. (1980) also cited a specimen collected by Macoun from the same locality that could also be *Q. ellipsoidalis*, but this again is incomplete so cannot be determined with certainty.

While examining the material of *Q. velutina* in the University of Toronto herbarium (TRT), I noticed a specimen, consisting of twigs with well-developed terminal buds, mature acorns, and sun-foliage, collected in 1957 by Tamsalu from just west of Galt, that appeared to be markedly different from most specimens. It had been determined by Tamsalu as *Q. coccinea* (Scarlet Oak), but had subsequently been redetermined as *Q. velutina*. The records of *Q. coccinea* from southern Ontario were thoroughly investigated by Fox and Soper (1954), who concluded that these should be referred to other species (primarily *Q. palustris*, (Pin Oak) and *Q. velutina*). Investigation in the field during the summer of 1978 led to the discovery of similar trees scattered through North Dumfries Township in the Regional Municipality of Waterloo, and in the northern part of South Dumfries Township in Brant County. Three more localities have been found south of Brantford.

Identification of the Brant and Waterloo Oaks

The identity of these trees presented a number of problems. They clearly fell within a group of species centered on *Q. velutina* and *Q. palustris*. This group of species was the subject of a recent study by Jensen (1977a, b), who was able to demonstrate that *Q. rubra* (Red Oak), *Q. velutina* (Black Oak), *Q. shumardii* (Shumard's Red Oak), *Q. nuttallii* (Nuttall's Oak), *Q. coccinea* (Scarlet Oak), *Q. ellipsoidalis* (Hill's Oak), and *Q. palustris* (Pin Oak) were all reasonably distinct species. It quickly became apparent that four of the species discussed by Jensen were quite distinct from the Waterloo–Brant trees and could be eliminated as possibilities. These were *Q. palustris*, which has small very flat acorn cups and small acorns, and *Q. rubra, Q. shumardii*, and *Q. nuttallii* which have very large flat acorn cups and large acorns. The remaining three species, *Q. coccinea, Q. ellipsoidalis,* and *Q. velutina*, cannot be so readily distinguished. Typical *Q. velutina* can be identified by the large usually deeply lobed leaves; large, acute, distinctly angled, densely gray pubescent terminal buds; and the distinct fringe of scales on the acorn cup. However, *Q. velutina* is extremely variable and individuals can be found with the characteristic terminal bud, but with small leaves and the acorn cup not or scarcely fringed. *Quercus coccinea* can usually be identified by the presence of several concentric rings at the tip of the acorn, but this character is occasionally missing. *Quercus ellipsoidalis* has no unique characters, but it can be readily identified by a combination of characters, particularly the slender petiole; small, glabrous or sparsely pubescent terminal buds; and the small, turbinate, unfringed acorn cup. Table 1 lists some of the charac-

TABLE 1—Characters distinguishing *Quercus coccinea, Q. ellipsoidalis,* and *Q. velutina* derived from Jensen (1977b) compared with data from Ontario specimens of *Q. velutina* and *Q. ellipsoidalis*

	coccinea (Jensen)	*ellipsoidalis* (Jensen)	*velutina* (Jensen)	*ellipsoidalis* (Rainy River, Kenora)	*velutina* (Ontario)
Length of leaf blade (mm)	111–160	60–110	(60–)(a)111–160	90–130	110–190
Width of leaf blade (mm)	101–150	57–100	(57–)101–150	75–100(–115)	80–145
Petiole diameter (mm)	0.97–1.44	0.68–0.96	0.97–1.44	0.8–1	(0.9–)1.0–1.4
Terminal bud length (mm)	(2.6–)5.7–9	2.6–5.6	5.7–9	3.0–4.3	(4.5–)5.5–7.5
Terminal bud strongly angled	– (rarely +)	–	+	–	+
Terminal bud indumentum	Pubescent at apex	Glabrous or pubescent at apex	Densely pubescent	Pubescent at apex	Densely pubescent
Acorn cup width (mm)	(9.8–)16–26.5	9.8–16	9.8–26.5	13–16	13–17
Acorn cup fringed	–	–	+ (rarely –)	–	+ (rarely –)
Acorn cup: pubescence of inner surface	Glabrous or pubescent at base	Glabrous	Pubescent all over	Sparsely pubescent all over	Pubescent all over
Acorn cup scale length (mm)	3.51–5.15	2.26–3.50 (–5.15)	3.51–5.16	3.2–4.0	(3.0–)3.5–5
Acorn with apical rings	+ (rarely –)	–	–	–	–

[a]Numbers in parenthesis are exceptional sizes, found in usually less than 10% of the sample.

ters which, according to the data published by Jensen (1977b), distinguish these three species. A number of other apparently diagnostic characters (e.g., twig diameter) used by Jensen appeared on Ontario material to be much too variable to be of any value in determining individual specimens. Jensen's data were not presented in such a way that they could be reliably used to determine individual specimens nor was this the purpose of his work. His data were obtained by calculating means of a series of measurements taken from selected trees. Therefore in some cases the extremes will be exceeded by individual measurements. Jensen also presented his data in a two-, three-, or four-character state form, which may grossly overstate the range of variation found in a particular species. Despite these shortcomings, these data seem to be useful for determining specimens. In addition to Jensen's data, Table 1 also includes, for comparison, data derived from Ontario specimens of *Q. ellipsoidalis* (Rainy River and Kenora districts) and *Q. velutina*. The data from Ontario *Q. ellipsoidalis* do not differ significantly from that of Jensen, except that the leaves are a little larger and the inner surface of the acorn cup is sparsely pubescent all over, not glabrous. The data from Ontario *Q. velutina* are also not markedly different from Jensen's data. The large difference in the figures obtained for acorn cup width is almost certainly due to the way in which Jensen scaled these data. If the Ontario data were scaled in the same manner a similar range would be obtained.

Table 2 presents comparable data derived from specimens collected from individual trees in Brant and Waterloo counties. The Tamsalu specimens and Ball numbers 78095, 78445, 79099, and 79445 agree well with *Q. ellipsoidalis* from northwestern Ontario and with Jensen's data. The other specimens show combinations of characters which make it impossible to attribute them to a particular species. For example, Ball 79436 most closely matches *Q. coccinea*, but the acorns are without the apical rings and this individual was growing adjacent to Ball 79445 (*Q. ellipsoidalis*) and about 200 m from Ball 79451 (*Q. velutina*). In view of the extensive evidence of hybridization between *Q. ellipsoidalis* and *Q. velutina* presented by Jensen (1977a) and others, it seems reasonable to assume that these individuals are of hybrid origin.

TABLE 2—Characters of *Quercus* specimens from Waterloo and Brant. (? character could not be observed)

	Tamsalu 15.VIII.1957 (TRT)	Ball 78095	Ball 78444	Ball 78445	Ball 79099	Ball 79436	Ball 79437	Ball 79445
Length of leaf blade (mm)	100	105	120–135	95–100	105–125	100–150	90–135	90–115
Width of leaf blade (mm)	80	100	115–120	80–85	110–130	95–125	70–110	90–110
Petiole diameter (mm)	0.7	0.8	0.9	0.8	0.8–1.0	0.9–1	0.7–0.8	0.6–0.8
Terminal bud length (mm)	3.0	3.5	4.0	4.5	4.0–5.2	3.8–4.8	3.5–4.0	3.5
Terminal bud strongly angled	–	–	–	–	–	–		
Terminal bud indumentum	Pubescent at apex	Pubescent at apex	Pubescent at apex	Pubescent at apex	Pubescent at apex	Pubescent at apex	Pubescent almost all over	Pubescent at apex
Acorn cup width (mm)	15	15	12	11	13–16	16–17	16–19	12
Acorn cup fringed	–	–	–	–		–	–	–
Acorn cup: pubescence of inner surface	Sparsely pubescent all over	?	Sparsely pubescent all over	?	Glabrous or hairy at base	Glabrous	Glabrous or sparsely pubescent	?
Acorn cup scale length (mm)	4.0	4.0	3.0	2.5	2.5–3.5	3.5	3.5–4.5	3.0
Acorn with apical rings	–	–	–	–	–	–	–	–

Distribution and Ecology of *Q. ellipsoidalis* in Southern Ontario

Investigations in the field and in a number of herbaria (DAO, TRT) have shown that *Q. ellipsoidalis* or trees that are probably derived from *Q. ellipsoidalis* × *velutina* hybrids are largely restricted to North Dumfries township in the Regional Municipality of Waterloo and to South Dumfries township in Brant County. A few individuals have been found in two other localities in Brant County adjacent to the Grand River. Recently (1981) John Sewell has discovered a roadside tree in northwestern Norfolk County about 12 km southwest of Brantford. The known distribution of these trees, except for the Norfolk County locality, is shown in Figure 2a.

This population of *Q. ellipsoidalis* represents a major eastward extension of the range of this species, being over 200 km east of the nearest localities in Michigan (Figure 1). Whereas such a large disjunction is unusual, the area of Waterloo and Brant counties in question is well known for the large number of uncommon species which occur there, many with disjunct distributions. These include species of dry open habitats such as *Aureolaria virginica* (False Foxgloves) and *Swertia caroliniensis* (Columbo), and species of open wet habitats such as *Carex lupuliformis* (a sedge), *Eleocharis rostellata* (Spike Rush), and many others (Herriott 1905; Montgomery 1945; Soper 1962).

Little information can be given on the ecology of *Q. ellipsoidalis* in Waterloo and Brant counties. Almost all of the stations are in old fence rows or hedgerows. In several localities the trees are growing very close to extensive tracts of natural forest, but despite extensive searches either none were found in these forests or only a few trees were found at the edge. In a few instances the trees were also found growing close to ponds or small lakes which are frequent in this area, and in one locality they appeared to have invaded an abandoned field. The soil in almost all cases had a high sand content and in several localities the trees were associated with herbs which are generally regarded as prairie elements, e.g. *Andropogon gerardii* (Big Blue Stem), *A. scoparius* (Little Blue Stem), *Sorghastrum nutans* (Indian Grass), and *Lespedeza capitata* (Bush clover). One station is very close to the only known locality of *Bouteloua curtipendula* in Brant County (Montgomery 1956).

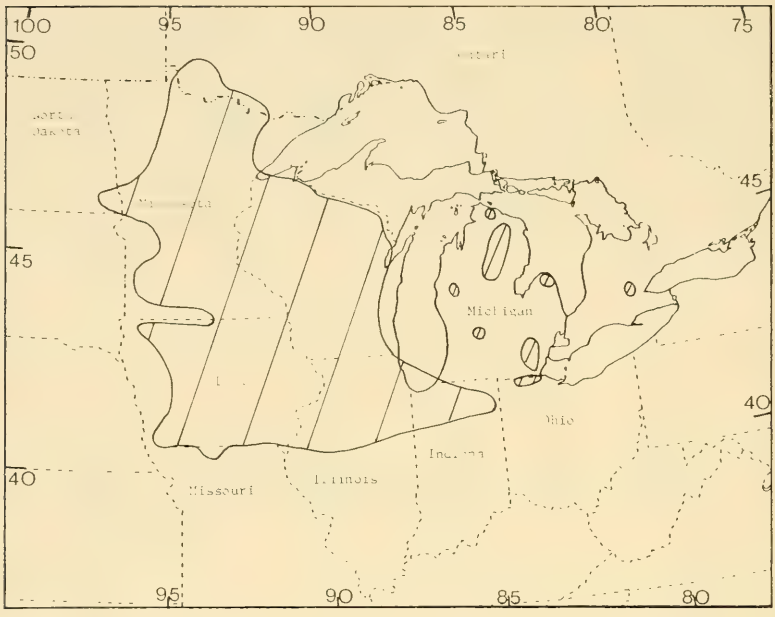

FIGURE 1. North American distribution of *Quercus ellipsoidalis* (after Little 1971). Note disjunct localities in Michigan and Ohio.

The historical geography of Dumfries township was the subject of a detailed study by Wood (1958, 1961). The township was first surveyed in 1816–1817 and Wood was able to construct a map of the vegetation of that period based on the surveyor's notes. Extensive areas in the southern and eastern halves of the township were described as "oak plains," "plains," or "meadows." An area (about 5 × 4 km) west and southwest of Galt was covered by "thickets" consisting of scrubby individuals of pine, oak, poplar, and hazel. Also mentioned were "briars," "white thorn," "plum bushes," and "cherry." Such "thickets" suggest an area under recolonization following a relatively recent major disturbance. At the northern end of the "thickets" an area of about 4 × 1 km was described as recently burnt, thus suggesting that the "thickets" were the result of an earlier more extensive fire. The approximate area covered by these vegetation types is shown in Figure 2b. Another brief description of the vegetation south of Galt was provided by Fergusson (1833). He described the area (pp. 130–131) as ". . . an extensive range of open, grove-like woodland, principally oak, and the trees so dispersed as to not interfere materially with the plough. It had much of the appearance of some of the wildest part of English park-scenery . . . It was a lovely landscape, with a greater range open to the eye than usually occurs in the interior of Canada." These early 19th century descriptions of Dumfries township suggest that much of it consisted of extensive areas of dry grassland with numerous open-grown oak trees which did not form a continuous canopy and which was subject to disturbance by fire. Such a description conforms well with modern accounts of the ecology of *Q. ellipsoidalis* in Wisconsin and northwestern Ontario (Curtis 1959; Maycock et al. 1980). A comparison of Figure 2a and b shows that there is a good correlation between the present-day distribution of *Q. ellipsoidalis* in Dumfries township and the areas of vegetation that were suitable for it in 1816–1817. Many of the apparently suitable areas from which the species is now missing (e.g. east of Paris) have been subject to total destruction by quarrying in recent times or by urbanization.

The absence of this species from other areas of southwestern Ontario is a little puzzling and may be due to oversight. Nevertheless, the absence of specimens from these areas suggests that, if it does occur there, it must be extremely rare. It should be noted that this disjunct population of Hill's Oak is in serious jeopardy. Most of the localities mapped consist of less than five trees often in a poor state of health. None occur along roads which have been improved in recent years (e.g. Highways 24, 24A, and the new Highway 97) and the locality 2 km south of Galt is on a dirt road which is in the process of being widened and improved with virtually all hedgerow trees being destroyed. The

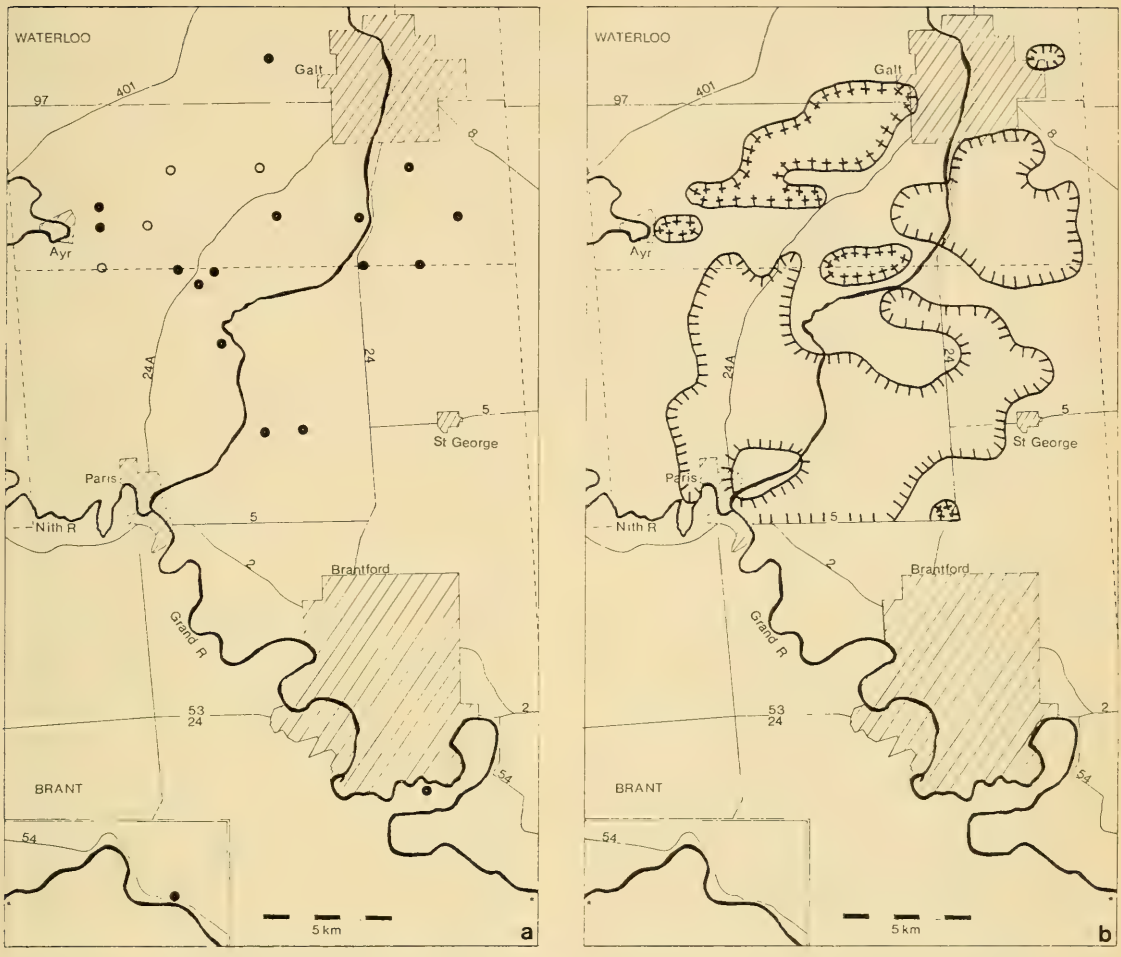

FIGURE 2.(a) Distribution of *Quercus ellipsoidalis* in Brant County and Waterloo County (now the Regional Municipality of Waterloo). One locality in Norfolk County not mapped. Herbarium specimens, •. Sight records,○. County boundaries indicated by broken line. Ontario highways indicated by unbroken line with number. Location of insert indicated by asterisk.

2(b) Occurrence of "plains," "oak plains," "thickets," and "burnt areas" in Dumfries township as noted in 1816–1817 (after Wood 1958, 1961). Plains and oak plains — boundary marked by straight lines. Thickets and burnt areas — boundary marked by crosses.

largest group of trees (probably over 100) seen is just south of Blue Lake, 5 km west of St. George. These occur along the road, in hedgerows and in an old field which has been partially subdivided into large house lots. A few individuals occur in Pinehurst Conservation area, 8 km north of Paris, and on the edge of forest tracts being managed by the Ontario Ministry of Natural Resources. Unfortunately the normal methods of forest management employed in these areas are not likely to encourage reproduction of *Q. ellipsoidalis*. The species undoubtedly requires open, somewhat disturbed, habitats to reproduce successfully, and it may also be encouraged by fire (Curtis 1959).

The following is a list of specimens of *Q. ellipsoidalis* and *Q. ellipsoidalis* × *velutina* on which Table 2 and Figure 2 are based. Also listed are some additional localities for *Q. ellipsoidalis* in northwestern Ontario which were utilized in compiling Table 1 and which were not listed by Maycock et al. (1980).

Specimens of *Q. ellipsoidalis* and *Q. ellipsoidalis* × *velutina*

Kenora District

S. shore of Kakagi Lake, 2 miles (3 km) south of Blacky Bay. 49°10′N. 93°49′W. 8.VIII.1957. P.A. Bentley 57535 (DAO, TRT) (sub *Q. rubra*).

Rainy River District

Quetico Provincial Park. Prairie Portage at Sucker Lake. 24.VII.1957. Garton 4910 (DAO, TRT) (sub *Q. rubra*).

Wild Land Reserve. 5 miles (8 km) below town on Rainy River. 7.VII.1961. Garton 8861 (DAO, TRT) (sub *Q. rubra*).

Brant County

On the Grand River between Caledonia and Brantford, near Middleport. 1970. Gilmour (DAO). Onondaga twp. 1/2 km west of Middleport. 43°06′N. 80°05′W. Large tree at edge of roadside and cornfield. 28.VI.1979. Ball 79099 (TRTE). Brantford twp. 4 km south of Brantford in the Oxbow. 43°07′N. 80°14′W. Hedgerow-roadside trees. 28.VI.1979. Ball 79088 (TRTE); 20.IX.1979. Ball 79436, Ball 79437, Ball 79445 (TRTE). South Dumfries twp. Spottiswood Lake. 17.VIII.1957. Dore & Montgomery 16850 (DAO). South Dumfries twp. East side of Spottiswood Lake. 43°15′N. 80°22′W. Edge of open area dominated by *Sorghastrum nutans, Andropogon scoparius, Lespedeza capitata, Aster azureus, Solidago nemoralis.* 30.VIII.1978. Ball (and Maycock) 78381 (TRTE). South Dumfries twp. c. 1 km west of junction of Highways 5 and 24 along road to Blue Lake. 43°14′N. 80°18′W. Roadside tree. 30.VI.1978. Ball 78110 (TRTE). South Dumfries twp. 2 km west of junction of Highways 5 and 24. 43°14′N. 80°19′W. Roadside-hedgerow trees. 26.VIII.1980. Ball 80169, 80171, 80172, 80173, (TRTE). South Dumfries twp. South of Blue Lake. 43°13′30″N. 80°20′W. Numerous roadside-hedgerow trees. 26.VIII.1980. Ball 80178, 80179 (TRTE). South Dumfries twp. c. 1 km east of Blue Lake. 43°14′N. 80°20′W. Roadside-hedgerow tree. Ball 78111 (TRTE). South Dumfries twp. County Line Road c. 200 m east of Hwy. 24A. 43°15′N. 80°23′W. Roadside-fencerow tree. 26.VI.1978. Ball 78095 (TRTE). South Dumfries twp. County Line Road c. 1 km west of Hwy. 24A. 43°17′N. 80°24′W. Roadside at edge of small lake, associated with *Andropogon scoparius, A. gerardii, Lespedeza capitata.* 26.VIII.1980. Ball 80191, 80192 (TRTE).

Regional Municipality of Waterloo, North Dumfries twp.

Roadside 1–1/2 (2 km) west of Galt. 15.VIII.1957. A. Tamsalu (TRT, HAM). c. 2 km west of Galt along regional road 46 (formerly Hwy. 97). 43°22′N. 80°22′W. Roadside tree. 21.VI.1978. Ball 78048 (TRTE). 5 km south of Galt on road running west from the Grand River. 43°19′N. 80°19′W. Roadside-fencerow tree. 23.VI.1979. Ball 78065 (TRTE). 6 km south west of Galt, 3 km west of Grand River close to Waterloo forest, Sudden tract. Hedgerow-roadside trees. 43°18′N. 80°21′W. 23.VI.1978. Ball 78064A, B (TRTE). 1 km south of Galt, 1 km east of the Grand River. 43°20′N. 80°17′W. Hedgerow-roadside trees. 6.IX.1979. Ball 79400, 79401 (TRTE). 1–1/2 km WSW of Branchton, on County Line Road. 43°18′N. 80°16′W. Roadside-hedgerow tree. 26.VI.1978. Ball 78096 (TRTE). Concession VII, lot 31, near Ayr. 6.IX.1941. Montgomery 849 (DAO). 2 km E. of Ayr. 43°18′N. 80°26′W. Hedgerow-roadside trees. 5.IX.1978. Ball 78444, 78445 (TRTE).

Regional Municipality of Haldimand–Norfolk

Windham twp. 2–1/2 km SW of Scotland. 43°00′N. 80°24′W. Roadside tree. 22.II.1981. J. Sewell (TRTE).

Acknowledgments

My thanks to Craig Campbell for his helpful comments and suggestions, William Crins for checking specimens in a number of herbaria, and to the curators of the herbaria cited. This work was financed by Natural Sciences and Engineering Research Council grant No. A6494.

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Received 12 November 1980
Accepted 6 March 1981

Seasonal and Daily Use of Plant Communities by Sharp-tailed Grouse (*Pedioecetes phasianellus*) in the parklands of Alberta

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Moyles, D. L. J. 1981. Seasonal and daily use of plant communities by Sharp-tailed Grouse (*Pedioecetes phasianellus*) in the parklands of Alberta. Canadian Field-Naturalist 95(3): 287–291.

Sharp-tailed Grouse (*Pedioecetes phasianellus*) showed specific preferences for different plant communities at different times of the year. Grassland and grassland – low shrub transition zones were selected throughout the year, with trees being used primarily in winter and spring. Grouse were recorded using marsh vegetation only during winter. Except in winter and spring when Sharp-tailed Grouse were seen in trees, they generally used open cover during early morning, moving into taller vegetation by midday. In the afternoon and evening they moved back into more open vegetation. In summer, females with broods selected grassland and grassland – low shrub transition zones throughout the day while males and females without broods selected taller vegetation. The extent of Trembling Aspen (*Populus tremuloides*) cover around an arena was inversely correlated with the numbers of males recorded on it and to the total number of grouse recorded within 0.8 km of the arena.

Key Words: Sharp-tailed Grouse (*Pedioecetes phasianellus*), parkland, habitat use, Alberta.

Sharp-tailed Grouse (*Pedioecetes phasianellus*) occupy a variety of habitats in North America, from open grasslands and sage brush through parklands to early successional stages and open portions of mixed woods and boreal forests (Aldrich 1963). They have also adapted to areas where agriculture has created a mosaic of native vegetation and cultivated lands that provides food and cover (Evans 1968; Pepper 1972). Descriptions of vegetation used in spring and in summer, particularly by females with broods (Hamerstrom 1963; Artmann 1970; Pepper 1972), and during winter (G. A. Ammann. 1957. The prairie grouse of Michigan, Game Division, Department of Conservation, Lansing, Michigan; Marshall and Jensen 1937, *cited in* Johnsgard 1973) are available, but Evans (1968) noted that a proper understanding of the habitat requirements of sharptails throughout the year is lacking. In this paper I report preferences shown seasonally and daily by Sharp-tailed Grouse for certain plant communities in aspen parkland of east-central Alberta.

Study Area

The study area was located in Camp Wainwright Military Reserve (54°48′N; 110°55′W), 12 km southwest of Wainwright, Alberta. The area (28 km^2) included grassland, grassland – low shrub transition zones, patches of low shrubs, tall shrubs, and low shrub – tall shrub transition zones, copses of trees, and wetlands.

The grasslands (19.2%) were dominated by Blue Grama Grass (*Bouteloua gracilis*) and Speargrass (*Stipa comata*), with Brome (*Bromus inermis*) and fescue (*Festuca* spp.) also in appreciable amounts. Predominate forbs in the grasslands and grassland–shrub transition areas were Pasture Sage (*Artemisia frigida*) and Prairie Sage (*A. gnaphalodes*), asters (*Aster* spp.), Yarrow (*Achillea lanulosa*), Golden Aster (*Chrysopis villosa*), goldenrod (*Solidago* spp.), and Wild Strawberry (*Fragaria glauca*). Horsetail (*Equisetum* spp.) was also common in these areas. Patches of Bearberry (*Arctostaphylos uva-ursi*) were found in south-facing slopes. Less commonly, forbs such as Golden Bean (*Thermopsis rhombigolia*), milk-vetches (*Astragalus* spp.), Purple Prairie Clover (*Petalostemon purpureum*), Gaillardia (*Gaillardia aristata*), vetches (*Vicia* spp.), Silverweed (*Potentilla anserina*), Three-flowered Avens (*Geum triflorum*), and locoweed (*Oxytropis* spp.) were present.

In the ecotone between aspen copses and grassland, shrubs such as Chokecherry (*Prunus virginiana*), Saskatoon (*Amelanchier alnifolia*), Wolf Willow (*Elaeagnus commutata*), roses (*Rosa acicularis* and *R. woodsii*), and snowberry (*Symphoricarpus albus* and *S. occidentalis*) were often growing in a scattered pattern and intermixed with grasses and forbs, such as sages, goldenrods, Yarrow, and Golden Aster. This grassland – low shrub transition zone covered 25.5% of the study area; 8.6% was covered by thick, discrete clumps of low shrubs less than 1 m in height, particularly Chokecherry, Snowberry, Wolf Willow, and Saskatoon; these clumps varied from 0.5 m^2 to 10 m^2. Grasses dominated the understory in these patches.

Low shrub – tall shrub transition zones (21.8%) were usually found on the edges of aspen copses and dominated by Trembling Aspen (*Populus tremuloides*) saplings or Chokecherry bushes to 3 m in height. The understory was usually dense small shrubs, usually Chokecherry and Saskatoon intermixed with aspen saplings. Patches of 1 to 2 m high Wolf Willow were usually open with grasses composing almost all of the understory.

Aspen dominated all stands of tall shrubs (10.2%), some of which were found in discrete clumps but most were located beside trees. The understory was usually dense with a variety of small shrubs including Chokecherry, Saskatoon, and aspen. Northern Bedstraw (*Galium boreale*), Cream-

coloured Vetchling (*Lathyrus ochroleucus*), Harebell (*Campanula rotundifolia*), and anemones (*Anemone* spp.) were commonly intermixed with sparse grasses.

The aspen corpses (13.3%) varied from about 3 m^2 in area up to about 11 ha; average size was about 0.7 ha. The understory beneath the mature trees was usually open with some aspen, Chokecherry, or Saskatoon saplings, grasses, and Vetchling and asters. These copses were intermixed with patches of grassland and grassland-shrub transition zones throughout the study area. The aspen was expanding into the grassland community, probably as a result of no large-scale burning for at least 12 years, and only limited grazing in portions of the area between 15 May and 15 November each year.

Wetlands occupied about 2% of the study area. These were mesic areas, with little open water and occupied with sedges (*Carex* spp.). Willows (*Salix* spp.) grew along the borders in bands from 1 to 5 m thick. Balsam Poplar (*P. balsamifera*) also grew along the borders of these wetlands.

The study area was undisturbed apart from military activity which affected the area in two ways: (1) small wildfires occurred sporadically, never exceeding 3 ha during the study, and (2) extensive use of all-terrain and tracked vehicles created trails and openings through wooded and shrubby areas.

Methods

The study area was searched systematically with dogs from mid-May 1975 to early January 1977. In addition, seven male Sharp-tailed Grouse were fitted with radio transmitters in autumn 1975, 12 males in spring 1976, and 13 males in autumn and winter 1976. Locations of all grouse encountered, both during searches and by radiolocation, were noted before flushing if possible, otherwise at the point of flushing. Weather conditions (wind speed, temperature, cloud cover, and presence or absence of moisture on the vegetation) were noted at the time of each sighting.

The vegetation within a 1-m radius of each location of sighting was classified into one of seven classes (Table 1). The distribution of these sightings was compared with the availability of the same classes within the study area.

The impact of weather on the type of vegetation used by grouse was tested with a multiple regression analysis, using a hierarchial approach (Nie et al. 1975).

To examine the impact of aspen forest expansion on the use of display arenas, the area covered by aspen stands within a radius of 800 m of nine arenas was measured with a planimeter from aerial photographs (1 cm = 190 m) taken in 1962 and 1975.

Results and Discussion

Based on all observations over the entire year, Sharp-tailed Grouse were not distributed randomly relative to available plant communities except for

TABLE 1—Description of seven plant communities in the Aspen Parkland of Alberta used by Sharp-tailed Grouse

No.	Community	Description
1	Grassland	Dominated by grasses and forbs
2	Grassland – low shrub transition	A mixture of grasses, forbs, and woody plants less than 1 m in height
3	Low shrub	Dominated by wood plants less than 1 m in height
4	Low shrub – tall shrub transition	A mixture of woody plants less than 3 m in height
5	Tall shrub	Dominated by woody plants greater than 1 m but less than 3 m in height
6	Trees	Dominated by woody plants greater than 3 m in height
7	Marsh	Dominated by willow and sedge

grassland – low shrub transition and for tall shrubs (Figure 1). They preferred grassland (chi-square test, $P < 0.05$), low shrub and trees ($P < 0.05$), and avoided low shrub – tall shrub ($P < 0.05$). Marsh was used only in winter ($P < 0.05$). Considering the sightings by season provided a somewhat different picture (Figure 2). In spring (1 April to 15 June) grouse selected tree communities, seemingly for cover and

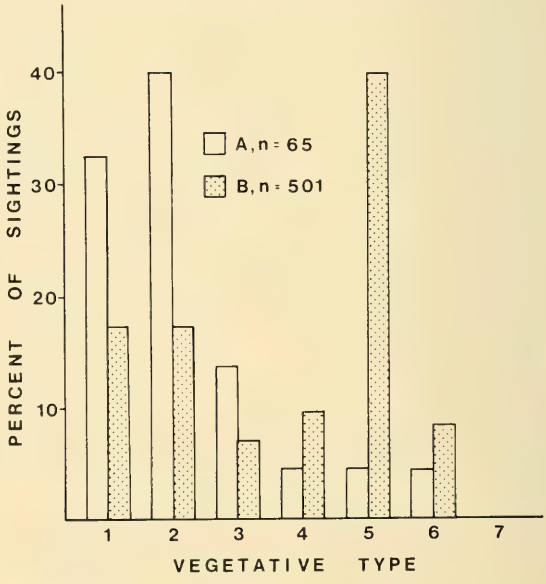

FIGURE 1. Selection of the plant communities (Table 1) by Sharp-tailed Grouse, based on 2322 sightings in 1975 and 1976 (A) as compared to the relative coverage of the plant communities (B).

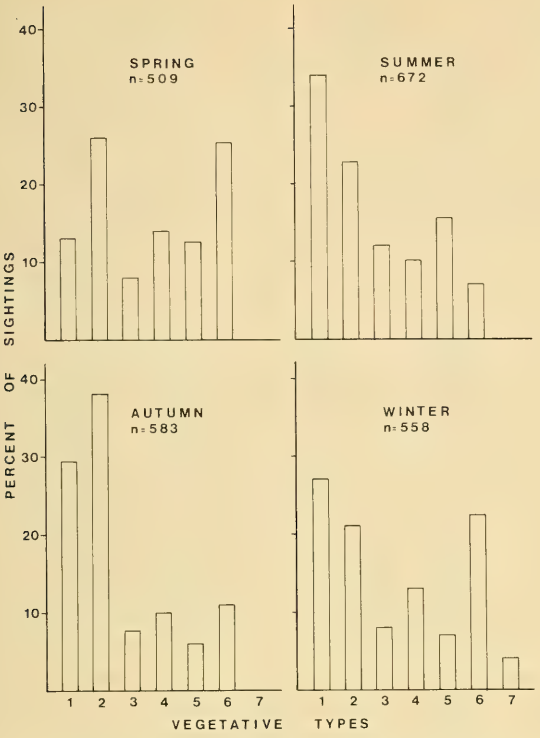

FIGURE 2. Selection of various classes of vegetation (Table 1) by Sharp-tailed Grouse during four seasons based on 2322 sightings in 1975 and 1976. Spring, 1 April to 15 June; Summer, 16 June to 31 August; Autumn, 1 September to 15 November; Winter, 16 November to 31 March.

food. In summer (16 June to 31 August) they selected primarily grassland and tall shrub communities, particularly tall shrub with sparse understory during midday. In autumn (1 September to 15 November) about 70% of grouse sightings were in grassland or grassland – low shrub transition communities. These communities offered both food (insects and fruits) and roosting cover for grouse. Grouse in winter (16 November to 31 March) used grassland and trees. They fed on aspen buds and roosted in grassland and in the lee of the trees. Marsh vegetation was used in winter when sedges and willows provided cover and food.

Sharp-tailed Grouse selected different plant communities throughout the day (Figure 3). In spring, grouse were observed feeding mainly in grassland – low shrub transition zone and trees during early morning, remaining in the taller vegetation throughout midday. They moved back into grassland – low shrub transition and grassland communities after midday apparently seeking food and roosting cover. During the summer the grouse apparently fed in the grasslands during early morning, sometimes moving into heavier cover, perhaps for shade and protection from predators, during midday, and then back into more open vegetative types, again probably seeking feeding and roosting cover, in the evening (Figure 3). In autumn grouse used the open vegatative communities in early morning, apparently for feeding, occasionally moving into taller, heavier cover by midmorning. From midday to dark, grouse selected grassland – low shrub transition, apparently for food and roosting cover. However, during winter, grouse were often seen in the morning and midday perched in aspen trees, often eating buds, then moving into more open cover including (frozen) marsh during midday, and roosting predominantly in the low cover in the evening (Figure 3).

During summer females with broods used grassland and grassland – low shrub transition significantly more than other adult grouse (Figure 4), including both males and females without broods (G test, $P < 0.05$). These observations agree with Hamerstrom (1963) and Pepper (1972), who recorded broods in similar habitats on study areas in Wisconsin and Saskatchewan. Adult grouse without broods selected taller vegetative types, particularly tall shrubs. The heavier vegetation probably provided better cover from avian predators as well as cooler microclimate during the hottest part of the day. However, the relationship between weather and plant community selected by the grouse was not strong. Only 3.7% of the variation in cover chosen by grouse could be explained by weather. Other factors such as food requirements, presence of conspecifics, familiarity with an area, and avoidance of predators may have been of more importance in influencing choice of vegetation by these grouse.

The relationship between the amount of continuous aspen cover within a radius of 0.8 km of a display site, or arena, of a group of male Sharp-tailed Grouse and the number of these displaying males present on each of nine arenas in 1976 (Figure 5) suggests that numbers may be inversely related to the total coverage of aspen. Data on numbers of sharptails attending three arenas were available from 1968 to 1978. Changes in aspen cover within a radius of 0.8 km of these three arenas between 1962 and 1975 were compared with the numbers present in 1968 and 1976–1978 (Table 2). The apparent inverse relationship also suggests that with increasing percentage of aspen cover fewer Sharp-tailed Grouse used the area. Caldwell (1976) determined that arenas in aspen parkland in central Manitoba ceased to be used by grouse when the percentage area dominated by grasses within

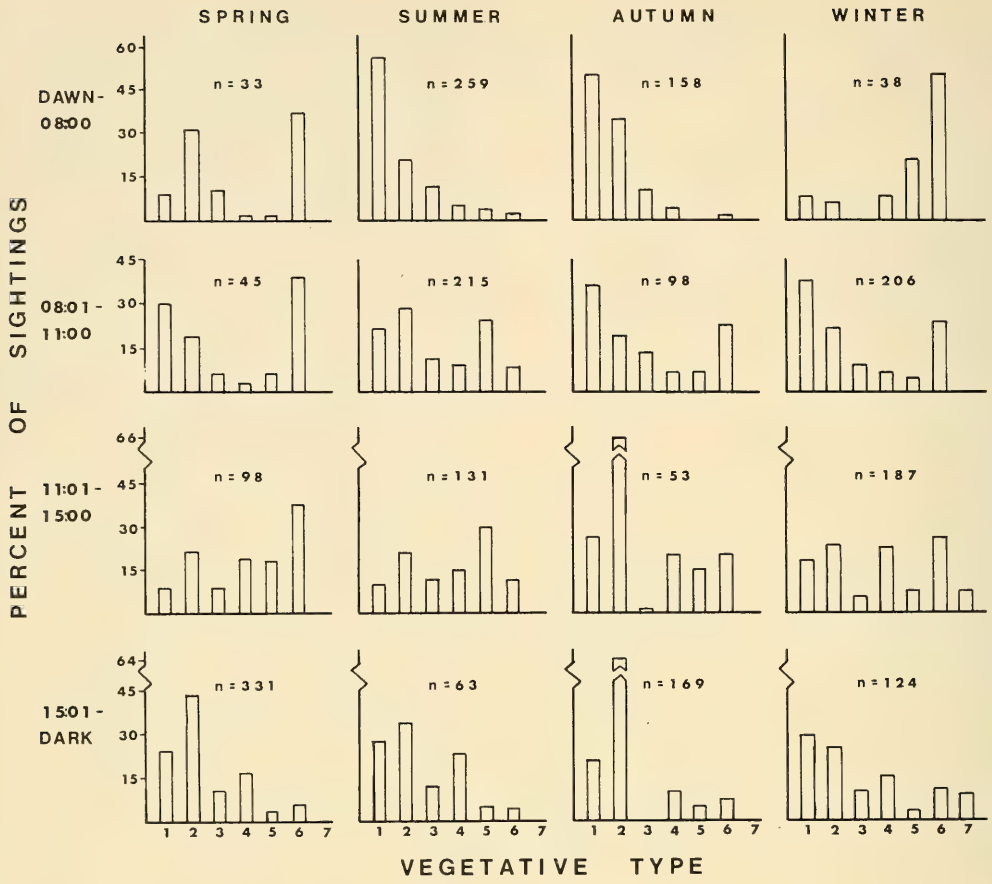

FIGURE 3. Use of various plant communities (Table 1) by Sharp-tailed Grouse throughout the day during the four seasons. (During winter the time periods used are dawn to 08:00; 08:01 to 11:00; 11:01 to 14:00; 14:00 to darkness; on account of shorter daylight period at this season).

0.8 km radius of the arena fell to less than 58%. Pepper (1972) reported positive correlations between the number of summer observations and the amount of upgrazed native grass-shrub and tame haylands within 1.6 km of arenas and between attendance of grouse on arenas during spring display and the number of sharptails seen within 1.6 km of the arena in summer. Thus a decrease in the number of displaying males also implies a decrease in the total population.

In summary, I believe that Sharp-tailed Grouse inhabiting the parklands of central Alberta have specific preferences for different plant communities at different times of the year and of the day. This suggests that a mosaic of plant communities, particularly grasslands and grassland-shrub mixtures with extensive ecotone, provides optimum habitat. Furthermore, expansion of the aspen community at the expense of the grassland community reduces the rela-

TABLE 2—Relationship between increase in aspen cover within a 0.8-km radius of three arenas between 1962 and 1975 and decline in numbers of males displaying on these arenas from 1968 to 1978

Arena	Increase in aspen cover (%)	No. of displaying males			
		1968	1976	1977	1978
1	16	18	5 (28)[a]	1 (6)	0
2	14	30	13 (43)	11 (37)	10 (33)
3	31	31	7 (23)	0	0

[a]Percentage of males in 1968.

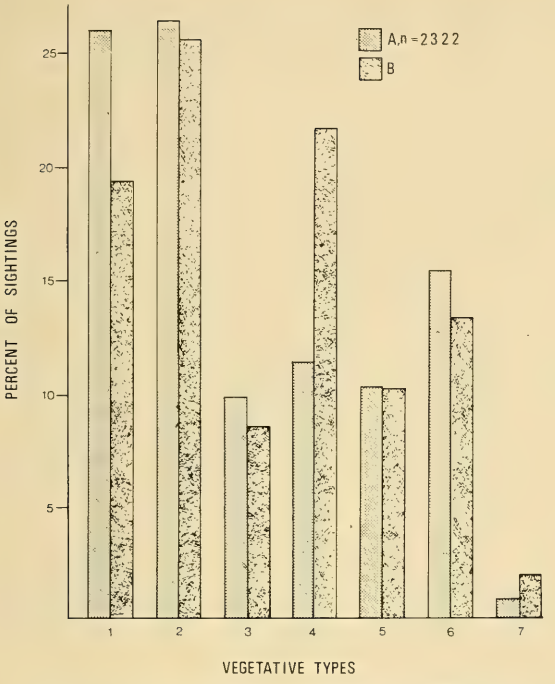

FIGURE 4. Use of various plant communities (Table 1) by female Sharp-tailed Grouse with broods (A) and by broodless adults (males and females) (B) during the summers of 1975 and 1976.

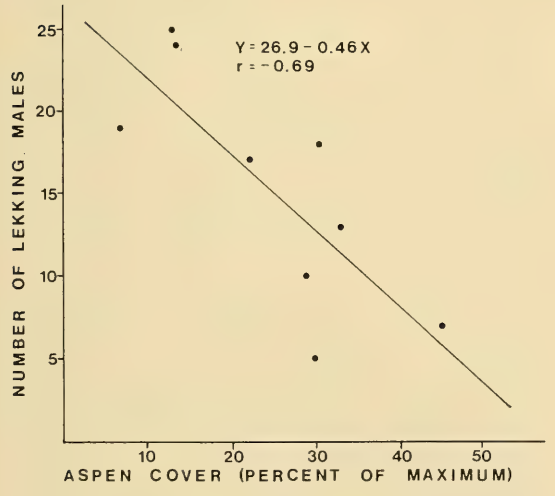

FIGURE 5. Relationship between area of aspen cover (expressed as a percentage of the total) within a circle of radius 0.8 km from an arena and the number of displaying male Sharp-tailed Grouse on the arena.

tive availability of the various vegetative types, and as a consequence seems to reduce the utility of the area to grouse as suggested by lower numbers on arenas.

Acknowledgments

I thank D. A. Boag for his assistance during the field work and for comments on this manuscript. Two anonymous referees also made valuable comments on earlier drafts. D. Alton, P. Harris, L. Ramsay, K. Smyth, and D. Wade assisted in the field at various times. Major R. Bridgeman allowed me to work in Camp Wainwright and R. Fyfe of Canadian Wildlife Service kindly allowed me the use of the Canadian Wildlife Service facilities at Wainwright. I received financial support from the Alberta Fish and Wildlife Division, a National Research Council of Canada Postgraduate Scholarship, and an operating grant (2010) to D. A. Boag. K. Smyth drew the figures.

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Received 30 November 1978
Accepted 1 March 1981

Movements and Haulout Behavior of Radio-tagged Harbor Seals, *Phoca vitulina*

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Pitcher, Kenneth W., and Dennis C. McAllister. 1981. Movements and haulout behavior of radio-tagged Harbor Seals, *Phoca vitulina*. Canadian Field-Naturalist 95(3): 292–297.

Movements, haulout area fidelity, and haulout frequency of Harbor Seals (*Phoca vitulina*) were studied in the Kodiak Island area, Alaska, by relocating radio-tagged animals captured on a large hauling area. Eight of 35 radio-tagged seals were found on hauling areas other than the capture site. The longest movement was 194 km and one seal crossed 74 km of open ocean. Movement rates up to 27 km/d were recorded. There appeared to be considerable fidelity to one or two specific haulout locations by individual radio-tagged animals. Resident, radio-tagged seals of a large hauling area were hauled out during 50% of the daily radio checks in June and 41% from 1 August to 5 September. On an individual basis, frequency of haulout ranged from 16 to 80% of the days.

Key Words: Harbor Seals, *Phoca vitulina*; Gulf of Alaska, radio-tagged, movements, haulout behavior.

In common with other pinnipeds, Harbor Seals (*Phoca vitulina*) spend much of their lives in the ocean. At times they haul out of the water onto reefs, beaches, ice, or other suitable substrata where they rest, give birth, and suckle their young. At this time they can be most easily and accurately counted. Several workers have attempted to census Harbor Seal populations by counting hauled-out animals (Rosenthal 1968; Pearson and Verts 1970; Calambokidis et al. 1979). However, because of insufficient information regarding haulout area fidelity and the proportions of populations visible, such counts served only as minimum estimates. A recent study suggests that on the average Harbor Seals spend about 44% of their daily activity budget hauled out (Sullivan 1979). Most published information, based primarily on repetitive observations of recognizable individuals, suggests that at least some animals return repeatedly to the same hauling area (Boulva and McLaren 1979; Calambokidis et al. 1978; Reijnders 1976; Knudtson 1974).

Harbor Seals are considered to be relatively sedentary animals with local movements associated with tides, food, reproduction, and season (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969). These impressions were the results of general observations rather than records of individual movements. The only scientific information of which we are aware on movements of individual seals is from recoveries of animals tagged as pups (Divinyi 1973; Bonner and Whitthames 1974; Boulva and McLaren 1979).

In this study we used radio-tracking techniques to monitor movements and haulout behavior of individual Harbor Seals thereby collecting new and more comprehensive information on the range of movements, movement rates, haulout area fidelity, and frequency of haulout of Harbor Seals.

Methods

This study was conducted in the Kodiak Island area of the Gulf of Alaska (Figure 1). The primary study site was the southwestern hauling area on Tugidak Island (56°27′N, 154°47′W) where up to 9000 Harbor Seals have been counted on a 3.2-km stretch of gravel beach. Field work was conducted between 8 May and 9 September 1978. Thirty-five seals (including 24 mature females, 5 immature females, 5 mature males, and 1 immature male) were captured on the southwestern hauling area, immobilized with Ketamine hydrochloride (Ketelar; Parke, Davis and Company), and fitted with radio transmitters attached with a bracelet around the base of a hind flipper. The first 21 seals were captured between 8 May and 2 June. Capture operations were then suspended to avoid disturbance during pupping. Fourteen more seals were fitted with transmitters from 3 to 9 July. The transmitters, fabricated by Cedar Creek Bioelectronics Laboratory of the University of Minnesota, operated on separate frequencies in the 164 to 165-MHz range. Signals could be received only when the seals were hauled out. Maximum range of the transmitters was about 8 km. Radio-tagged seals were also marked with individually recognizable color combinations of cattle ear tags placed in hind flippers and vinyl flagging attached to the transmitters to serve as backup identifiers to detect transmitter failure or loss.

Both numbers of radio-tagged seals and total numbers of seals hauled out on the southwestern haul-

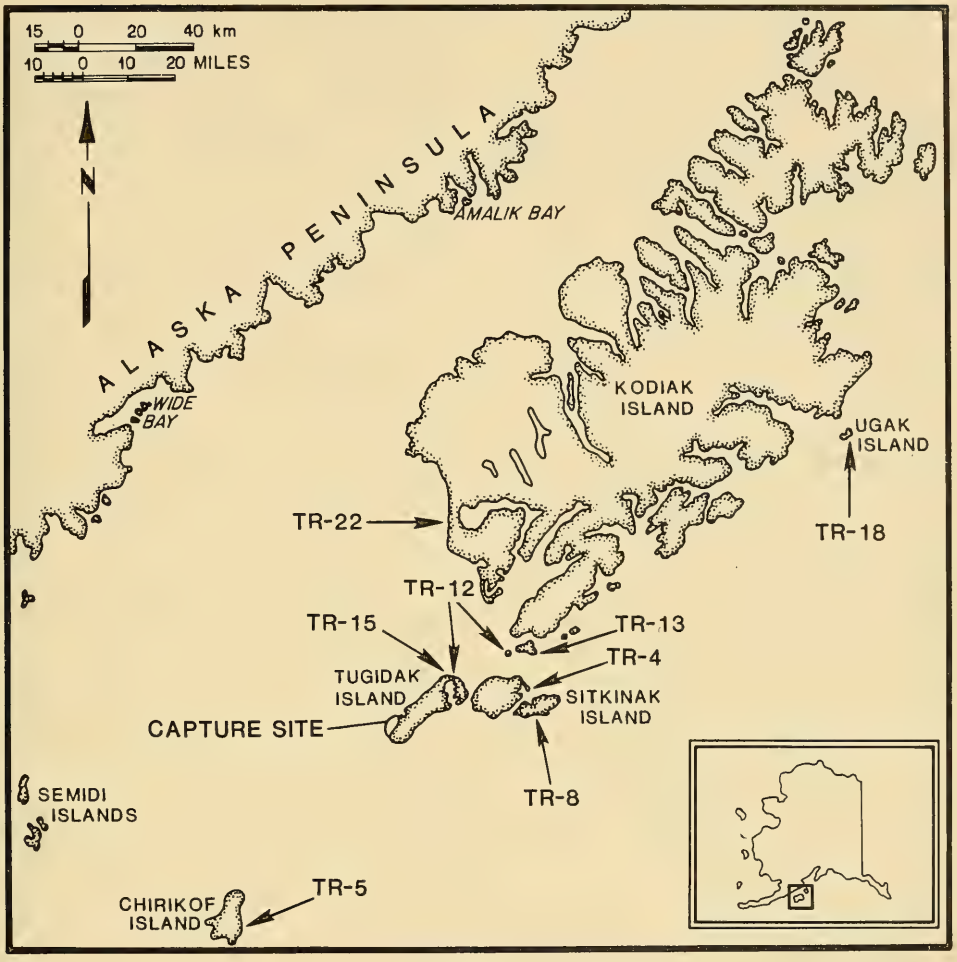

FIGURE 1. Gulf of Alaska study area showing locations of radio-tagged (TR) Harbor Seals found at haulouts other than the capture site on southwestern Tugidak Island.

ing area were monitored on a near daily basis during June and from 1 August to 5 September. Additional observations of radio-tagged seals were made from 9–31 May, but behavior of the animals may have been affected by the disturbance of ongoing capture operations. Radio checks and counts of seals on the southwestern hauling area were made from the top of 30-m bluffs abutting the beach. A portable radio-tracking receiver with hand-held Yagi antenna was used for the onsite radio checks. Seals were directly counted from the bluffs or from polaroid prints taken from the bluffs. Hauled-out seals were examined with 10× binoculars to locate radio-tagged individuals and the results compared with radio checks to detect radio failures or losses. Radio checks and counts were timed to coincide with daytime low tides when maximum numbers were usually hauled out.

Aerial, radio-tracking surveys, using a scanning receiver, were flown in a Bellanca Scout fixed-wing aircraft or a Bell 206 helicopter. Twenty-seven surveys, totaling 53.6 h, were flown to locate radio-tagged seals that moved from southwestern Tugidak to other hauling areas. Coverage of the surveys included most of the shoreline and all of the known, major haulouts in the Kodiak Island group. Chirikof Island and the Semidi Islands were surveyed twice. The coast between Wide Bay and Amalik Bay on the Alaska Peninsula was surveyed once. Surveys were

flown during lower stages of the tide when the most seals were usually hauled out.

Results and Discussion

Movements

Eight radio-tagged seals (six females and two males) were relocated 17 times at hauling areas other than the capture site. The longest movement was a minimum of 194 km to Ugak Island (Figure 1). Another animal crossed 74 km of open ocean to Chirikof Island and then returned to southwestern Tugidak. The other movements ranged between 26 and 74 km. The general pattern for these animals seemed to be for them to remain at the new site for some period of time rather than using many locations. Twelve of 17 relocations of radio-tagged seals on haulouts other than southwestern Tugidak were clustered in the northern Tugidak, Sitkinak, southern Kodiak area (Figure 1), which are the nearest hauling areas to southwestern Tugidak. Several different "types" of movements occurred. One seal (TR-18) made a long move to another hauling area which it appeared to use for the remainder of the study period. Another (TR-5) made a long move to a hauling area, then returned to southwestern Tugidak where it appeared to stay for the remainder of the summer. Two radio-tagged seals (TR-4, 13) alternated between two haulouts. Three seals (TR-8, 15,22) were found at hauling areas other than southwestern Tugidak only once. No correlation between sex and age of the radio-tagged seals and extent or type of movement was apparent; however, sample sizes of all groups except adult females were very small.

It was probable that additional movements of radio-tagged seals occurred. Many of the other transmitter-equipped seals were absent from southwestern Tudigak for extended periods (Figure 2). Only occasional radio-tracking surveys were flown and radio-tagged animals which were not hauled out at the time or in the area of the survey would not have been found.

Information on average movement rates was derived by dividing minimum distances between consecutive sighting by elapsed time. Rates for four animals were 24, 19, 27, and 26 km/d. These rates were minimums because actual routes traveled were unknown and actual travel times were no doubt less than observed in most cases.

Information previously available on movements of individual Harbor Seals was from the recoveries of animals which had been tagged within several weeks of their birth (Bonner and Witthames 1974; Boulva and McLaren 1979; Alaska Department of Fish and Game, unpublished data). They documented dispersal of juveniles up to 250 km from large pupping areas. Mansfield (1967) remarked on the wandering or dispersal of young Harbor Seals, referring to them as "rangers." Additional insight into the range of Harbor Seal movements comes from offshore sightings. Spalding (1964) reported observations of Harbor Seals 50–65 km offshore in the Gulf of Alaska, and Wahl (1977) saw a seal 80 km off the coast of Washington State.

Haulout Area Fidelity

There appeared to be considerable fidelity to specific haulout areas by individual radio-tagged seals. Twenty-three of 31 (74%) seals that were relocated after capture were found only at the capture site. Of the eight animals that were found on haulouts other than southwestern Tugidak, three were found on the same haulout more than once. Only one seal was found on more than two sites and it was found on only three. Additional use of haulouts other than southwestern Tugidak may have gone undetected, but the consistency of these data leads to the conclusion that few sites are generally used.

Other investigators have also presented evidence suggesting considerable site fidelity. Calambokidis et al. (1978) suggested that both year-round site loyalty and long-distance movements occurred in Harbor Seal populations in Puget Sound. They based this on repetitive observations of uniquely marked individuals and fluctuations of counts of seals on hauling areas. Knudtson (1974) and Reijnders (1976) reported observations of the same animals returning repeatedly to the same hauling area. Divinyi (1973) collected a tagged Harbor Seal on the southwestern Tugidak haulout where it had been tagged as a pup three years earlier. Boulva and McLaren (1979) saw recognizable individuals hauled out in the same area day after day during summer.

Frequency of Haulout and Proportion Hauled Out

Insight into what proportion of the population was represented by counts of hauled-out seals was gained by examining haulout histories of radio-tagged seals (Figure 2). Since more than one hauling area was sometimes used and since only southwestern Tugidak was regularly monitored, it was impossible to quantify precisely the haulout frequency of all radio-tagged seals. To alleviate this problem we subsequently classified certain radio-tagged seals as southwestern Tugidak residents by excluding those found hauled out at other locations and those which were absent from southwestern Tugidak for extended periods. We then examined the haulout data from these animals during two periods with frequent monitoring and minimal disturbance (1–30 June and 1 August–5 September).

In June, resident radio-tagged seals were found hauled out during daily radio checks on an average of

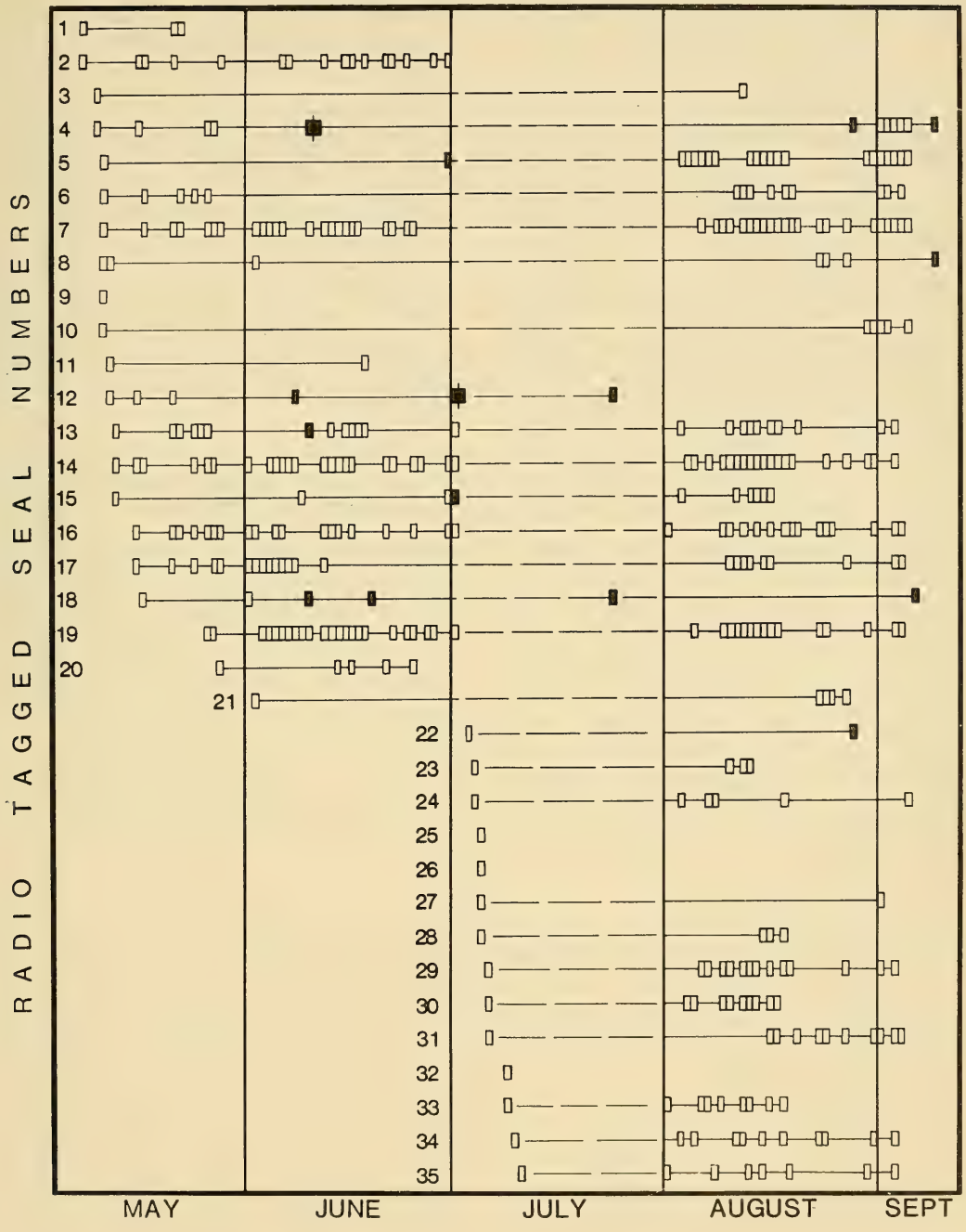

FIGURE 2. Haulout patterns of radio-tagged Harbor Seals on southwestern Tugidak Island showing the presence or absence of each individual during daily radio checks. Open box, present; dark box, found on other haulout; capture operation caused some disturbance between 8 May and 2 June; 25 valid radio checks between 1 and 30 June; no onsite radio checks 2–31 July; 31 valid radio checks between 1 August and 5 September.

50 ± 7% (95% confidence interval) of the days, and between 1 August and 5 September they were found hauled out on 41 ± 5% (95% confidence interval) of the days (Table 1). On an individual basis, frequency of haulout ranged from 16% (TR-20 during June and TR-24 during August–September) to 80% (TR-19 during June) of the days. If the resident radio-tagged animals were representative of the population, the average number of seals hauled out during the daily radio checks probably represented between about 35 and 60% of the total population.

Our findings agree quite well with the results of certain other studies. Sullivan (1979) found that Harbor Seals spent an average of 44% of their daily activity budgets hauled out. Summers and Mountford's (1975) estimate of Harbor Seals in the Wash, Great Britain, based on mark–recapture studies, was considerably higher than numbers seen hauled out. Finley (1979) speculated that midday counts of Ringed Seals (*Phoca hispida*) represented about 70% of the population based on a recognizable individual that was observed 71% of the time.

The effects of capture, handling, and attachment of the transmitter package on the behavior of radio-tagged seals was largely unknown but cannot be entirely ignored. Haulout behavior of radio-tagged seals observed on southwestern Tugidak appeared to be normal. However, some seals developed abrasions where the bracelet encircled the ankle, apparently because of excess rigidity of the bracelet. In one instance, both the health and choice of haulout location of a radio-tagged seal appeared to be influenced by the abrasion resulting from the transmitter attachment. TR-22 was relocated 56 d after capture on a beach not normally used as a haulout by Harbor Seals. She appeared thin and weak. Her hind flipper at the point of transmitter attachment was badly chafed and infected. We recaptured her and removed the transmitter.

Four radio-tagged seals were never relocated after release. They may have moved beyond the range of the aerial surveys or not have been hauled out during any of the surveys. If the transmitters failed or were lost they would not have been relocated during aerial surveys, but would have been seen on southwestern Tugidak where visual searches were routinely made. Mortality, either related or unrelated to capture and transmitter attachment, could explain lack of contacts. Hammond and Elsner (1977) reported delayed deaths of seals several hours after they appeared to be recovered from immobilization with Ketamine hydrochloride.

Acknowledgments

This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) office. Field assistance was provided by G. Browning, P. Smith,and D. Stevens. Pilots during aerial radio-tracking surveys were P. Buker, R. Wright, and Lts. (NOAA) Christman and Layden. Drafts of the manuscript were critically reviewed by J. Burns, D. McKnight, K. Schneider, and D. Siniff. Thanks are due to R. Reicle and D. Siniff of the University of Minnesota for their assistance and advice on radio-tracking procedures.

TABLE 1—Haulout frequency of resident radio-tagged Harbor Seals on southwestern Tugidak Island

Resident seal number	1–30 June			1 August – 5 September			
	Days checked	Days hauled out	Proportion days hauled out	Resident seal no.	Days checked	Days hauled out	Proportion days hauled out
2	25	11	0.44	5	31	19	0.61
7	25	16	0.64	6	31	9	0.29
14	25	16	0.64	7	31	22	0.71
16	25	11	0.44	13	31	10	0.32
17	25	9	0.36	14	31	19	0.61
19	25	20	0.80	16	31	15	0.48
20	25	4	0.16	17	31	9	0.29
				19	31	15	0.48
				24	31	5	0.16
				29	31	13	0.42
				34	31	10	0.32
				35	31	7	0.23
Overall	175	87	0.50	Overall	372	153	0.41

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Received 8 November 1980
Accepted 5 March 1981

Reproduction, Distribution, and Population Size of Largemouth Bass, *Micropterus salmoides*, in an Oligotrophic Precambrian Shield Lake

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Numbers of self-sustaining, resident Largemouth Bass, *Micropterus salmoides*, ▷ 145 mm FL) in Tadenac Lake (45°04′N; 79°57′W) (308 ha) were estimated at 350 in 1975 and 213 in 1976, based on trap net data and angling returns of tagged fish. Trap net catches included fish 1+ to 7+ years of age, but 1+ and 2+ fish were not fully sampled because of gear selectivity. Biomass was calculated at 0.39 (1975) and 0.21 (1976) kg $\cdot$ ha^{-1} for the entire lake, and 4.94 (1975) and 2.63 (1976) kg $\cdot$ ha^{-1} for littoral habitat used by Largemouth Bass. Adults spawned in shallow (< 1.4 m) sheltered bays usually (75%) on basal leaves of *Eriocaulon septangulare* in late May and early June. Only 0.8% of the lake bottom provided potential nesting sites. Nine completed nests were found in 1975, 15 in 1976. Only two nests failed to produce viable progeny each year. Mean survival rate to hatch in successful nests was 0.978. Both juveniles and adults inhabited weeded littoral areas (8% of the lake surface area), which offered the warmest water available, although maximum epilimnetic temperatures remained below the final preferendum for the species. The size of natural populations of Largemouth Bass in oligotrophic Precambrian Shield lakes is apparently limited by the extent of adequate warm weedy littoral areas.

Key Words: distribution, Largemouth Bass, *Micropterus salmoides*; nesting sites, oligotrophic, population estimates, Precambrian, reproduction.

Largemouth Bass (*Micropterus salmoides*) inhabit numerous oligotrophic lakes on the Ontario Precambrian Shield near the northern fringe of their native range (Robbins and MacCrimmon 1974). Littoral fish communities in these lakes may include the Smallmouth Bass (*M. dolomieui*), Walleye (*Stizostedion vitreum vitreum*), Northern Pike (*Esox lucius*), or Muskellunge (*E. masquinongy*). Most of these lakes have deeper waters suited to salmonids and coldwater fish communities.

Tadenac Lake, one of these oligotrophic Precambrian Shield lakes, offers a unique opportunity to study an indigenous self-sustaining population of Largemouth Bass. This lake has no road access, no habitations, very limited controlled angling, and, therefore, has been immune from appreciable cultural stresses. The purpose of our study was to describe the reproduction, density, and biomass of the species in a typical oligotrophic Precambrian Shield lake and compare the data with that from warm eutrophic waters where abundant populations of Largemouth Bass normally occur.

Study Area

Tadenac Lake (45°04′N; 79°57′W) is located within the Precambrian Shield of Ontario in Georgian Bay Township. The lake has a surface area of 308 ha and a maximum depth of 30 m, and is typically oligotrophic in physical and chemical characteristics (mean depth, 8.2 m; August thermocline, 7–9 m; pH, 6.95; conductivity, 36 μs $\cdot$ cm^{-1}).

Substrate within the littoral zone consists of sand, gravel, barren rock, and silt. In the shallow bays bulrushes, *Scirpus* sp.; sedges, Cyperaceae family; pickerel weed, *Pontederia* sp.; pond lilies (white and yellows), *Nymphae* sp.; *Potamogeton* sp.; and Pipewort, *Eriocaulon septangulare*, were abundant. The lake is surrounded by a conifer and mixed hardwood forest which has regenerated after the area was clear-cut before 1895. The ichthyofauna of the lake consists of 21 cold-water and warmwater species representing 11 families (Maraldo 1978).

A dam has maintained the level of Tadenac Lake above that of the adjacent waters of Georgian Bay since 1925. Midsummer surface levels of Tadenac Lake were about 0.5 m above Georgian Bay during the study. Before 1925, there would seem to have been a free access to Largemouth Bass between Georgian Bay and Tadenac Lake waters.

Material and Methods

Population Density

In 1975, six 1.8-m and four 2.4-m trap nets (vertical measurements of box, lead, and wings) were operated in Tadenac Lake from early May to mid-October. In

1976, nine 2.4-m, one 1.8-m, and one 1.2-m trap nets were fished from late April through September (Figure 1). Nets were lifted at weekly intervals, except during the early spring when they had to be tended more frequently. Catch per unit effort is the total number of bass captured divided by the total number of net-days in that month. Additional specimens of Largemouth Bass were captured for examination, tagging, and subsequent release by use of a 60-cm small mesh trap net, a 2.5-cm monofilament nylon gill net, Plexiglas fry traps (Casselman and Harvey 1973), a 9-m seine, and by angling. Fish retained in anglers' creels were also examined.

Fork length was measured to the nearest millimetre, and fish were weighed to the nearest 25 g (if $\geq$ 1.0 kg) or 10 g (if $<$ 1.0 kg). Fish greater than 140 mm FL were tagged with either strap or spaghetti tags, and finclipped. Smaller fish ($<$ 140 mm FL) were only finclipped. Scale samples were taken from the body at the posterior tip of the depressed pectoral fin. The determination of age and growth from scales has proven valid for fish to age 7+ (Maraldo and MacCrimmon 1979). Each fish was released at the point of capture after tag numbers and vital statistics had been recorded.

Population estimates were calculated from 1975 and 1976 trap net catches using the Schnabel method with confidence limits determined by treating the number of recaptures as a Poisson variable and, for comparative purposes, were computed also by the Petersen formula (Ricker 1975). The angling season (July and August) was divided into four equal periods with the number of unmarked and recaptured fish summed over each. Annual Petersen population estimates are the mean of the four values.

Proportions of the total catch in each age-class were multiplied by the population estimates and then by the mean weights for that year-class at the time of annulus formation (Maraldo and MacCrimmon 1979). Total biomass is the sum of these total weights for each year-class, and is expressed as per unit area for both the entire lake and the littoral area.

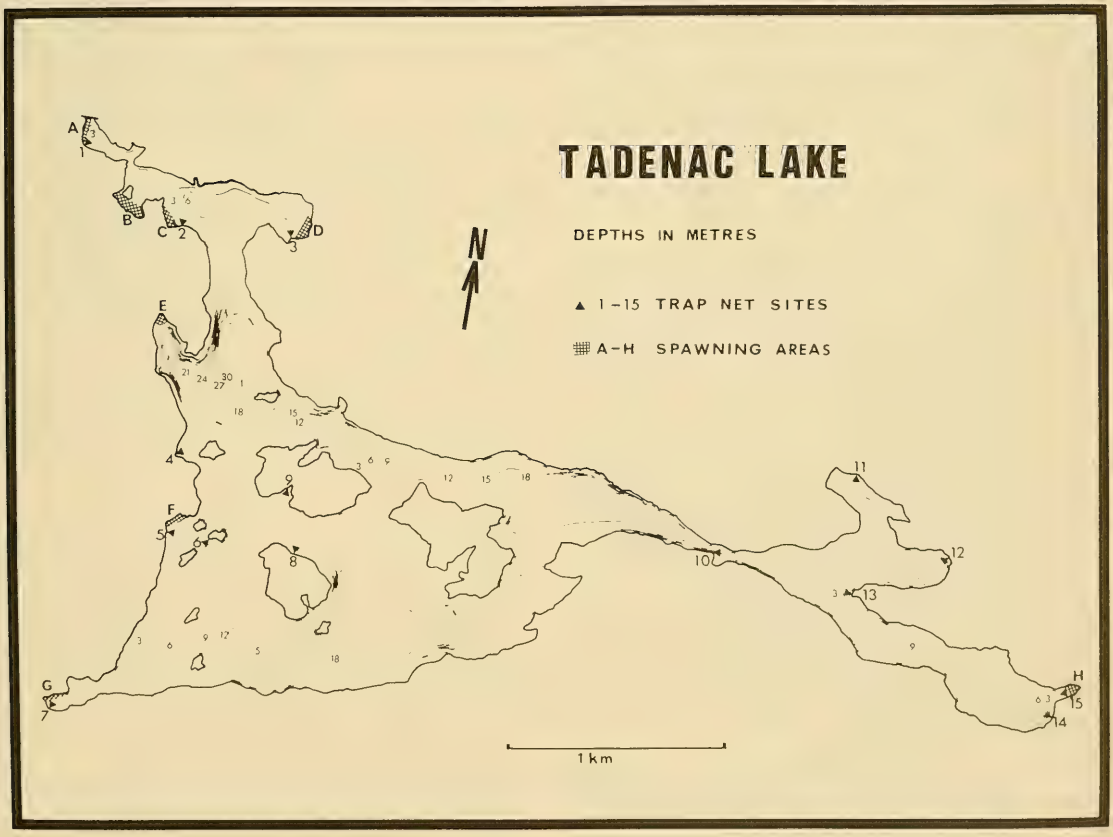

FIGURE 1. Bathymetric map of Tadenac Lake showing trap net locations and spawning areas.

Reproduction

Daily searches of shallow areas (≤2 m) for evidence of nest building or reproduction by Largemouth Bass began on 19 May 1975 and 11 May 1976. The bright yellow eggs and the nearby presence of the male parent identified active nests. The depth, distance from shore, availability of cover, and substrate type of nests were described. Nest sites were checked at 1- to 3-d intervals in 1975 and the status of embryos or larvae, presence or absence of adult, and water temperatures were recorded. In 1976, daily samples of embryos were collected from nine nests by sweeping the mouth of a large pipette across different areas of the nest while applying suction. Ratios of living embryos (yellow and translucent) to the total number of eggs per samples were then determined.

Distribution

Visual observation of the distribution of postemergent juveniles was continued, at least weekly, to the end of July in both years. From 9 August to 4 September of 1976, two Plexiglas fry traps (Casselman and Harvey 1973) were placed in areas where schools of Largemouth Bass had been observed previously. Daily observations and catches of juveniles were related to water temperature and depth, and to the size of the fish. Data from trap net catches provided information on distribution of larger fish, and on the movements of those previously tagged.

Results

Spawning and Embryo Survival in Nests

A total of eight spawning areas were located in shallow weedy bays, with fallen trees often present. In 1975, nine active nests were found in five bays between 21 May and 15 June, while 15 nests were located in six bays between 20 May and 5 June of 1976 (Figure 1). These nests were constructed between 1 and 10 m from shore at water depths of 0.2 to 1.4 m. They were typically circular, about 1 m in diameter, and most frequently (75%) situated on the basal leaves of *E. septangulare*. The site was usually cleared of settled organics by the male parent, but no depression was formed in the substrate. Spawning occurred less than 24 h after the initiation of nest preparation. The eggs were usually deposited in an area of about 0.3 m in diameter, located near the center of the nest. There is some evidence of spawning at the same locations in successive years, as one nest was found at the same site in both 1975 and 1976.

The presence of tags on adult fish did not appear to interfere with spawning activity. Tags were evident on two males guarding nests in 1975, and on six in 1976, one of which had been tagged only 8 d earlier. Guarding males taken by angling from nests for tagging or tag checks returned immediately to their nests on release. Guarding males generally remained within 2 m of their nests and defended the nest vigorously against intruders until schooling juveniles moved from the site. The embryos hatched 3 to 4 d after fertilization at water temperatures of 18.4 to 19.6°C. Free-swimming juveniles were first evident at the nest sites 4 to 6 d after hatching.

Ambient nest temperatures ranged from 17.5 to 23.0°C between 21 May and 22 June in 1975, and from 16.5 to 25.5°C between 27 May and 9 June in 1976. Water temperatures declined in 1975 from 22.8°C on 27 May to 18.0°C at some nests on the following day and did not increase again until mid-June. In 1976, however, the nest temperatures were lowest on the day of discovery, and increased daily thereafter. The one exception was a nest where low temperatures of 10.5 to 12.0°C prevailed between 20 and 23 May.

In 1975, two nests were unsuccessful; one became exposed to air by declining water levels and the other became almost completely covered by silt. Of nine nests under scrutiny in 1976, all but two successfully produced living embryos (sac-fry) at ambient incubation temperatures from 16.0 to 20.3°C. Mean daily survival estimates of embryos for all nine nests ranged from 0.062 to 0.995 (Table 1). Despite survival rates of 0.963 and 0.638 in nest 1 on 21 and 22 May, no embryos survived to emergence following exposure to ambient water temperatures of 10.4 to 10.8°C. In nest 7, the other unsuccessful nest, survival rates were 0.165 and 0.062 on 29 and 30 May at temperatures of 19.5 and 19.0°C. Mean daily surface water temperatures in all spawning areas during the sampling period of 27 to 31 May ranged from 18.4 to 20.3°C. There appeared to be no major changes in daily survival rates over the incubation period at the seven successful nests (Table 1).

Estimated survival of Largemouth Bass embryos in nest 9 was 0.993 on 30 May 1976 while in nest 7 survival was only 0.062 on the same day (Table 1). These two nests were located within 10 m of each other and were visually identical.

Distribution

A total of 23 sightings of schooling juveniles were made between 10 and 26 June 1975. All but one of these were in spawning areas. Water temperatures at the sites of these schools (18.5°C on 10 June; 26.5°C on 26 June) were similar to surface waters elsewhere in the lake. In 1976, eight sightings of schooling juvenile Largemouth Bass were made from 18 June to 4 July, all in spawning areas. Water temperatures at the sites of the schools were 23.0 to 25.0°C, typical of surface temperatures elsewhere in the lake. All schools sighted in both years were in <1.5 m of water with the fish generally concentrated in the upper 0.3 m of the water column.

TABLE 1—Estimated mean survival ($\hat{S}E$) to hatch of Largemouth Bass embryos in nests during May 1976

Nest	Location[a]	Date in May 1976						
		21	22	27	28	29	30	31
1	B	0.963$\hat{0}$.0473	0.638$\hat{0}$.0295					
2	A			0.951$\hat{0}$.0756	0.978$\hat{0}$.0074	0.955$\hat{0}$.0199		
3	B					0.978$\hat{0}$.0112	0.995$\hat{0}$.0071	0.977$\hat{0}$.0224
5	B					0.986$\hat{0}$.0103	0.987$\hat{0}$.0137	0.964$\hat{0}$.0260
6	B					0.980$\hat{0}$.0165	0.961$\hat{0}$.0238	0.954$\hat{0}$.0353
7	F					0.165$\hat{0}$.0469	0.062$\hat{0}$.0285	
8	H						0.984$\hat{0}$.0125	
9	F						0.993$\hat{0}$.0061	
10	D						0.979$\hat{0}$.0145	0.972$\hat{0}$.0201

[a]See Figure 1 for location of nest sites.

In 1976 a total of 65 young-of-the-year bass were captured between 10 August and 19 September in the two Plexiglas fry traps. Water temperatures at the traps ranged from 20.5 to 25.0°C during August and were within 1.5°C of the maximum recorded at any time in the lake.

Trap net fishing effort totalled 1740 and 1595 net-days in 1975 and 1976. Mean monthly catch per effort (Table 2) varied considerably over the fishing season with Largemouth Bass being most easily caught in May of both 1975 and 1976. Typically, catch per effort declined to a low in July 1975 and June 1976, followed by slight increases in August and September. The numbers of fish caught at each of the eight net sites used in both years (Table 3) did not differ significantly (t - test; $P < 0.05$).

Recaptures of tagged fish indicated little movement of Largemouth Bass between areas of the lake, except during late spring and early summer. Only 32% (8/25) and 23% (9/40) of the fish tagged in 1975 and 1976, respectively, were recaptured at a different site during the same year. Fish that had moved between net locations traveled minimum distances of 0.5 to 4.6 km in 1975 and 1976. In 1975, 7 of the 14 recaptures in May and June were at new locations while all 10 recaptures in July, August, and September were at the site of original tagging. This pattern was repeated in 1976 with 7 of 15 recaptures in June and July recovered at new locations. Individual fish tended to remain localized from one year to the next with only 4 of 10 fish, tagged in 1975 and recovered in 1976, recaptured at a location other than that of original capture.

Information on daily and seasonal movements of Largemouth Bass was also obtained from nesting males. Nests of two males were located within 100 m of the net where they had been tagged 8 and 30 d before, while two others had nests 0.4 and 1.8 km from the point of tagging 32 and 21 d previously. Later in the year, three males were recaptured in trap nets located within 100 m of their former nest, and another was captured by angling at distances of 1.1 km in July and 0.5 km in September.

Largemouth Bass aged 1+ to 7+ were caught in the trap nets in both 1975 and 1976 (Table 4). Fish aged 3+

TABLE 2—Catch per effort (N) by month for trap nets set in Tadenac Lake for Largemouth Bass

	1975	1976
April		0.143 (10)
May	0.294 (72)	0.144 (36)
June	0.086 (25)	0.087 (28)
July	0.047 (14)	0.089 (33)
August	0.057 (15)	0.089 (25)
September	0.064 (22)	0.098 (30)

(1973 year-class) dominated the 1976 catch, but this year-class had not been dominant in the 1975 catch, indicating that age 2+ fish were not fully recruited into the trap net fishery. Largemouth Bass in the angler catch ranged from 235 to 413 mm FL and 0.2 to 1.31 kg. Age 4+ fish dominated the catch of 1975 and age 3+ fish in 1976 (Table 4).

Tag loss in the year of tagging was 29.7% in 1975 and 20.0% in 1976. Tag loss between 1975 and 1976 among 34 fish recaptured was 70.6%.

Population Estimates

Because of gear selectivity, only fish greater than 145 mm FL are included in the trap net estimates of 350 fish (1.14 ha^{-1}) in 1975 and 213 fish (0.69 ha^{-1}) in 1976. The 95% confidence interval of the trap net estimates of 159 to 292 fish over the whole netting season in 1976 overlapped the 95% confidence interval of the 1975 estimate of 246 to 520 fish, indicating that the population size remained similar over the two years. Trap net estimates for May and June only fell within the 95% C.I. of the estimates over the entire netting season in both years (Table 5).

Biomass of Largemouth Bass in Tadenac Lake was estimated at 120.6 kg in 1975 and 64.2 kg in 1976, or 0.39 and 0.21 $kg \cdot ha^{-1}$ (Table 4). These are minimum estimates because of the incomplete vulnerability of the first three age-classes to the trap net fishery.

Means of the four annual population estimates based on angler returns of tagged fish were 266 and 242 individuals in 1975 and 1976. These estimates are within the 95% confidence intervals of the trap net estimates of 246 to 520 in 1975, and 159 to 292 in 1976; thus indicating good agreement between the two methods. Again, population estimates from angler

TABLE 3—Catch statistics for Largemouth Bass at various trap net sites in Tadenac Lake

Location [a]	Time period	Trap net size (m)	Water depth at trap mouth (m)	Substrate type	Catch	
					Number of fish	Percent of total
1975						
1	6 May–12 October	1.8	2.4	Silt	30	19.5
2	2 May–12 October	2.4	2.4–3.0	Silt	16	10.4
3	4 May–12 October	1.8	3.7	Silt	13	8.4
4						
5	4 May–29 June	2.4	2.4–3.0	Silt	6	3.9
6	6 May–12 October	1.8	3.7–4.5	Gravel–rock	2	1.3
7	2 May–12 October	1.8	2.4–3.0	Silt	6	4.5
8	1 July–12 October	2.4	4.5–6.7	Gravel–rock	0	0.0
9						
10	6 April–29 June	1.8	3.7–5.5	Rock	0	0.0
11	7 May–29 June	2.4	2.4–3.0	Silt	25	16.2
12	7 May–29 June	1.8	4.5–6.1	Sand–gravel	34	22.1
13	1 July–12 October	1.8	3.7–4.5	Rock	1	0.6
14	2 July–12 October	1.8	4.5	Gravel	4	2.6
15	3 May–12 October	2.4	4.5	Silt	16	10.4
1976						
1	21 April–27 September	1.8	2.7	Silt	35	21.6
2	20 April–27 September	2.4	2.4	Silt	18	11.1
3	20 April–27 September	2.4	4.3	Silt	23	14.2
4	21 April–27 September	2.4	4.3	Sand–gravel	7	4.3
5	21 April–27 September	1.2	1.8	Silt	3	1.9
6						
7	20 April–27 September	2.4	3.7	Silt	15	9.3
8						
9	21 April–27 September	2.4	4.9	Rock–gravel	0	0.0
10						
11	26 April–27 September	2.4	1.8–3.7	Silt	21	13.0
12	20 April–27 September	2.4	5.8	Sand–gravel	24	14.8
13						
14						
15	20 April–27 September	2.4	3.7	Silt	16	9.9

[a]Number refers to location in Figure 1.

TABLE 4—Age distribution, mean weights, and calculated biomass from trap net and angler catches.

	Trap net catches						Angler catches				
					Estimated biomass (standing crop)					Harvest	
Age-class	Number caught	Percent of total catch	Estimated total no. in population	Mean wt. (g)[b]	Total (kg)	Per area (kg·ha^{-1})	Number caught	Percent of total catch	Mean wt. (g)	Total (kg)	Per area (kg·ha^{-1})
1975											
0+	0	0	—	—	—	—	0	0	—	—	—
1+	17	14.5	43	7	0.30	0.001	0	0	—	—	—
2+	21	18.0	53	68	3.60	0.012	1	3.0	350	0.35	0.001
3+	14	12.0	36	205	7.38	0.024	5	15.1	390	1.96	0.006
4+	17	14.5	43	431	18.53	0.060	12	36.4	510	6.08	0.020
5+	24	20.5	61	697	42.52	0.138	8	24.2	690	5.52	0.018
6+	17	14.5	43	831	35.73	0.116	4	12.1	940	3.76	0.012
7+	7	6.0	18	702	12.64	0.041	3	9.1	1100	3.30	0.011
Total	117		297		120.70	0.392	33			20.97	0.068
1976											
0+	0	0	—	—	—	—	0	0	—	—	—
1+	12	11.4	23	15	0.34	0.001	0	0	—	—	—
2+	15	14.3	29	85	2.46	0.008	2	5.7	270	0.55	0.002
3+	47	44.8	90	250	22.50	0.073	22	62.9	370	8.12	0.026
4+	10	9.5	19	378	7.18	0.023	4	11.4	530	2.12	0.007
5+	5	4.8	10	625	6.25	0.020	4	11.4	930	3.71	0.012
6+	8	7.6	15	765	11.47	0.037	2	5.7	1040	2.08	0.007
7+	8	7.6	15	924	13.86	0.045	1	2.9	1310	1.31	0.004
Total	105		201		64.06	0.208	35			17.89	0.058

[a]Using May–June estimates from Table 2.
[b]Determined from back-calculated lengths (Maraldo and MacCrimmon 1979).

returns apply only to the size range of fish represented in the angler catch.

Discussion

The distribution of Largemouth Bass in Tadenac Lake is restricted to shallow (<3 m), weedy bays offering the highest summer water temperatures, with limited movements between these areas. Even in these bays, midsummer water temperatures do not approach the final preferendum of 30°C for Largemouth Bass young-of-the-year (Maraldo 1978) and older fish (Siler and Clayton 1975). With fish selecting those temperatures closest to the preferred temperature for the species, it is likely that 3 m is the lower limit of the normal summer distribution since the midsummer thermocline begins at 3-4 m. Although trap net data (Table 3) show catches of Largemouth Bass down to 6 m, these fish undoubtedly encountered the lead in much shallower water before entering the trap.

Because spawning was localized in only five different littoral sites in 1975 and six in 1976, there are obvious assemblages of adult fish at favored spawning locations, a phenomenon also noted by Kramer and Smith (1962). Using catch per effort data from the stationary trap nets as an index of movement (Table 2), it appears that local movements of fish within Tadenac Lake were greatest in May with a decline in June and July, followed by a slight increase in August and September similar to findings of Hasler and Wisby (1958).

To validate population estimates, we can reduce the problems of non-random distribution of marked fish and recruitment of new individuals into the fishery by considering data from only May and June. This interval coincides with the period of greatest movements of Largemouth Bass in Tadenac Lake, and covers a short time span during which there could be only a very limited recruitment of new individuals into the fishery. Combined May and June estimates of 297 and 201 Largemouth Bass in 1975 and 1976 (Table 5) are similar to those of 350 and 213 individuals made over the entire season. May and June estimates were within the 95% confidence intervals calculated for the whole season estimates in their respective years.

Computed estimates from fish recaptured by a different method (angling) than how initially captured for tagging (trap) reduces possible biases associated with differential vulnerability to capture between tagged and untagged fish, and from non-random distribution of fishing effort. Population estimates from angler returns were calculated from averaged data over four 2-wk periods during the angling season. By using this short time span for each estimate, the effects of recruitment on the population estimate were greatly reduced. Numbers of catchable-sized Largemouth Bass in the lake estimated from angler returns were 266 in 1975, and 242 in 1976. Both population estimates were within the 95% confidence interval calculated for the trap net estimates in that year, i.e., 246 to 520 individuals in 1975, and 159 to 292 individuals in 1976.

Calculated biomasses of Largemouth Bass in Tadenac Lake of 0.39 and 0.21 $kg \cdot ha^{-1}$ in 1975 and 1976 represent very low figures relative to other waters (Carlander 1977; Mahon and Balon 1977). About 25% of the total surface area of Tadenac Lake is less than 3 m deep with this percentage remaining relatively constant because of the dam at the outlet. If only that littoral area frequented by Largemouth Bass in used in the calculation, the total biomass per area becomes 1.56 and 0.84 $kg \cdot ha^{-1}$ in 1975 and 1976. The littoral area actually providing habitat suitable for Largemouth Bass (i.e. <3 m deep, excluding areas of rocky shelves and shoals, windswept sand beaches lacking aquatic macrophytes) is only 24.4 ha, representing 32% of the littoral zone, 8% of the total lake surface area, and 0.64% of the total volume. The biomass of Largemouth Bass for these areas of favored habitat is estimated at 4.94 $kg \cdot ha^{-1}$ (1975) and 2.63 $kg \cdot ha^{-1}$ (1976) representing a significant localized abundance.

As in other waters (Miller and Kramer 1971; Heidinger 1975), the spawning of Largemouth Bass in Tadenac Lake was confined to shallow bays sheltered from prevailing winds. Most nests were on one type of substrate (i.e., the basal leaves of *E. septangulare*). Similarly in Minnesota, Kramer and Smith (1962) found most nests located on mats of one kind of aquatic vegetation, *Eleocharis acicularis*. The potential spawing habitat in Tadenac Lake was estimated to be 2.6 ha representing about 0.8% of the lake bottom.

The spawning period of late May to early June for Largemouth Bass in Tadenac Lake was similar to that recorded in other waters in the northern parts of its range (Mraz et al. 1961; Kramer and Smith 1962; MacKay 1963). Water temperatures in most Largemouth Bass nests were within the 18.9 to 20.0°C range typical of the species (Robbins and MacCrimmon 1974).

Depths of water over nests, ranging from 0.2 to 1.4 m, agree also with that in other waters (Mraz 1964; Chew 1974; Robbins and MacCrimmon 1974), but are considerably less than the 1.1 to 7.5 m reported by Allan and Romero (1975). It is improbable that spawning occurred in the deeper water of Tadenac Lake because of the narrow muddy littoral shelf and the abrupt change in average water temperature from 18.9 to 7.5°C at the 3-to 5-m thermocline during the spawning season.

Mean estimates of survival to hatch of Largemouth Bass embryos in successful nests (0.978) are greater

TABLE 5—Estimated populations of Largemouth Bass in Tadenac Lake

	N	Confidence interval	Number marked	Rt	Size range FL (mm)	Size range Wt. (kg)
1975						
Schnabel estimate from trap nets						
Over whole season	350	246–520	150	30	145–467	0.05–1.98
May–June (only)	297	180–531	93	15	162–467	0.06–1.98
Petersen estimates from angler returns						
Early July (1–15)	184	51–1840	92	2	300–393	0.50–1.05
Late July (16–31)	242	103–756	93	5	264–413	0.35–1.25
Early August (1–15)	285	79–2850	95	2	280–379	0.35–1.07
Late August (16–31)	353	120–1767	106	3	235–367	0.18–0.90
Mean from angler returns	266					
1976						
Schnabel estimate from trap nets						
Over whole season	213	159–292	127	45	174–411	0.07–1.60
May–June (only)	201	112–409	66	11	222–411	0.15–1.60
Petersen estimates from angler returns						
Early July (1–15)	476	128–	68	1	273–420	0.34–1.39
Late July (16–31)	168	72–535	70	5	249–388	0.28–0.97
Early August (1–15)	237	81–1185	79	3	278–401	0.32–1.11
Late August (16–31)	85	41–213	85	7	—	0.20–0.95
Mean from angler returns	242					

than the values of 0.804 and 0.922 reported in Utah (Miller and Kramer 1971), and 0.65 to 0.94 in Minnesota (Kramer and Smith 1962). Incubation temperature fluctuations in successful Tadenac Lake nests were well within the 10 to 13°C range of thermal tolerance reported for Largemouth Bass embryos (Swallow 1968).

The importance of direct temperature effects on Largemouth Bass mortality is not clear. Coutant (1975) considered small temperature changes not to be responsible for high mortalities determining year-class strengths. Badenhuizen (1969) also concluded that early mortality in Largemouth Bass embryos may not be adequately explained by temperature effects alone. At both unsuccessful Tadenac Lake nests in 1976, males remained in attendance even after total egg mortality had occurred. This is in contrast to the suggestion by Kelly (1968) and Heidinger (1975) that lowered temperatures may induce nest desertion by the male. That the shallow littoral areas of Tadenac Lake are suitable for Largemouth Bass reproduction is confirmed by the successful hatching of embryos and the subsequent production of young-of-the-year fish in both years of study, by the presence of all year-classes from 1968 through 1975 in the trap net fishery, and by the continuous, although modest, sport fishery over the past century.

The ability of small oligotrophic lakes on the Precambrian Shield to sustain natural Largemouth Bass populations probably depends on the extent of warm littoral areas and the abundance of aquatic macrophytes. In typical northern oligotrophic lakes these conditions occur only in shallow backbays sheltered from wind action, where a rapid warm-up of water in the spring and early summer provides 18°C or higher temperatures satisfactory for reproduction while more open epilimnetic waters remain comparatively cold. Fry and Watt (1957) noted, for example, a unique population of Largemouth Bass present in Thomas Bay (45°30′N) on the south Georgian Bay shore of Manitoulin Island, and explained its presence by the more sheltered location and consistently warmer water than elsewhere in the locality. While there are numerous small eutrophic lakes within the Precambrian Shield thermally suitable for the Largemouth Bass, these may be too shallow to prevent diel or winter anoxia.

Although Largemouth Bass populations in oligotrophic Precambrian lakes are low, growth rates of individual fish are not suppressed (Maraldo and MacCrimmon 1979) and localized biomass may be adequate to support limited sport fishing, as in Tadenac Lake. In fact, the very limited Largemouth Bass habitats of these lakes are generally similar to the more generous environments prevailing in more southerly eutrophic waters. Thus it would appear that the extent of suitable habitat limits Largemouth Bass production at more northerly latitudes.

Acknowledgments

We thank the Tadenac Club Limited for providing access to their facilities and for financial assistance, Barra L. Gots for excellent technical support, and R. B. MacGregor for cooperation in the field. A research grant awarded to H. R. MacCrimmon from the National Research Council of Canada helped fund the study.

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Received 16 October 1980
Accepted 12 March 1981

Forestry Management Practices and Populations of Breeding Birds in a Hardwood Forest in Nova Scotia

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Freedman, B., C. Beauchamp, I. A. McLaren, and S. I. Tingley. 1981. Forestry management practices and populations of breeding birds in a hardwood forest in Nova Scotia. Canadian Field-Naturalist 95(3): 307–311.

Effects of forestry practices on the breeding birds of a hardwood forest in Nova Scotia were studied. Total breeding density on three uncut control plots was ($x \pm$ SD) 663 ± 145 pairs/km^2. Total breeding densities on three plots clear-cut 3–5 yr earlier were somewhat lower (588 ± 155 pairs/km^2), as were the densities on one thinned plot (550 pairs/km^2) and on two strip-cut plots (475 and 575 pairs/km^2), but differences between treatments were not statistically significant.

Marked differences, however, occurred in the species composition of the bird communities in the various plots. The most important breeding species on the control plots were Least Flycatcher (*Empidonax minimus*) and Ovenbird (*Seiurus aurocapillus*). In the clear-cut plots the bird community was dominated by Chestnut-sided Warbler (*Dendroira pensylvanica*), Common Yellowthroat (*Geothlypis trichas*), and White-throated Sparrow (*Zonotrichia albicollis*). The species mixtures of the thinned and strip-cut plots were intermediate between those of the control and clear-cut plots.

Key Words: forest birds, breeding density, hardwood forest, silviculture.

The forest-related industries are among North America's largest. Nevertheless, there are relatively few studies in which the effects of forestry on wildlife communities have been examined, especially for those perceived as being of little economic significance, such as small mammals and songbirds. Recent studies of changes in populations of breeding birds indicate that, for many types of coniferous forest communities, intensive harvest techniques, such as clear-cutting, generally cause short-term decreases in both abundance and breeding diversity, followed by rapid recovery to abundance and diversity levels that frequently exceed those of uncut control forests (recently reviewed in Crawford and Titterington 1979; Scott et al. 1980; Smith 1980). The rates and degrees of recovery in various coniferous forest types have been related to several factors, especially the rates of revegetation and the habitat diversity within the regenerating forest. Far fewer studies have examined the effects of forestry on the breeding birds of hardwood forests, and we are aware of only one study that has investigated such forests in the northeast (Webb et al. 1977). In addition, we are aware of only one study (Welsh and Fillman 1980) that was done in habitats modified by logging or silviculture in Canada, in spite of the large areas of land that are disturbed here each year.

In this paper we examine the changes in populations of breeding birds that occurred subsequent to various forest management practices in a hardwood forest in Nova Scotia.

Methods

All study plots were located in Kings County, Nova Scotia, near 44°50′N, 65°44′W. This falls within the Red Spruce–Hemlock–Pine zone (*Picea rubra – Tsuga canadensis – Pinus* sp.) of Louck's (1962) classification of maritime forests. However, the particular forest that we studied originated after a fire 70 years ago, and is now dominated by a mixture of northern hardwood species, especially Red and Sugar Maple (*Acer rubrum* and *A. saccharum*) and White and Yellow Birch (*Betula papyrifera* and *B. allegheniensis*).

Our study area has been subjected to experimental forestry manipulations, including strip clear-cuts of two widths, and silvicultural thinning. These were intended to examine effects on regeneration and growth of desirable tree species. In addition, operational clear-cutting of patches of forest had been done in the immediate vicinity. Thus, we were able to census breeding birds of hardwood forests in patch clear-cuts, strip-cuts, silvicultural thins, and control, uncut forests. All treatments were located within 3 km of each other, in a fairly homogenous hardwood forest.

All plots were rectangular and were laid out by compass and chain. The perimeter of each plot was marked at 30-m intervals with flagging tape, and all but the relatively small thinned treatment plot had a transect through the long axis of the plot, which was also flagged at 30-m intervals. The sizes of the plots were determined by the sizes of the various silvicultural treatments examined: the sizes and shapes of the control, uncut plots were similar to those of the patch

clear-cut plots. The thinned plot had been selectively cut to 45% residual basal area. The wider strip-cut plot had two 30-m-wide clear-cut strips; 45% of the plot was cut, leaving 55% in one central uncut strip. The other strip-cut plot had three 20-m-wide cut strips: 38% of the plot was cut, leaving 62% in two central residual strips. Relative amounts of cut and uncut habitat on the strip-cut plots was somewhat artificial, and we might have obtained different results to those described below if we had, for example, included additional uncut strips on the edges of our plots.

Birds on each plot were surveyed 10 times between 29 May and 9 July 1980. Eight censuses were made between dawn and 11:30, and two between 19:00 and 21:50. The spot-map method was used to census birds (after Williams 1936; Robbins 1978). We calculated the densities of breeding bird species having at least 0.5 territories on a plot. Species richness was estimated as the number of breeding species having at least 0.5 territories per plot. Some scarcer species may have been eliminated by this conservative treatment of richness, if they held large territories or were seldom observed.

Quantitative measurements of the plant communities were made in five evenly spaced 20 × 20 m quadrats per plot. Species and diameter at breast height of all trees on the plots were recorded. From these measurements, we calculated tree density (stems/ha), stem basal area (m^2/ha), and frequency of occurrence for individual tree species, and summed for the plot as a whole. Canopy height was measured on dominant trees using a clinometer. Shrubs in 10 evenly spaced 5 × 5 m quadrats per plot were tallied as to species and number of individual stems, from which we calculated species and plot shrub densities (stems/ha). The percent ground cover of the various ground flora species was estimated in twenty 1 × 1 m quadrats per plot. Owing to foliage overlap, some plots had ground cover values greater than 100%. In addition, at each of the 20 points where ground cover was measured, estimates were made of the percent canopy cover, by sighting vertically through a paper cylinder (4.2 cm diameter, 10.5 cm length), and estimating the surface area covered by tree foliage. These methods were modified from James and Shugart (1970).

Scientific names of birds are given in Appendix 1.

Observations and Discussion

The characteristics of the vegetation of the various plots are summarized quantitatively in Tables 1 and 2. Qualitatively, the vegetation of the control plots was dominated by the overstory, with only moderate shrub and ground flora contributions. Conversely, the clear-cut plots had virtually no overstory (a very low density of unmerchantable trees had been left standing), and the vegetation was dominated by shrubs (mainly stump sprouts of *Acer* spp., *Betula papyrifera*, and *Viburnum cassinoides* (Raisinbush), seedlings of *Prunus pensylvanica* (Pin Cherry), and thickets of *Rubus* spp. (raspberry), and by a relatively rich ground flora, compared with the uncut plots. The vegetation of the thinned plot was intermediate to that of the control and clear-cut plots. The overstory was composed of relatively large and well-spaced stems of *Acer saccharum* and *Fraxinus americana* (White Ash). These produced a canopy cover only about one-third of the control average. On the other hand, the density, species composition, and cover of the shrub and ground flora strata were roughly comparable to that of the clear-cut plots. The vegetation of the strip-cut plots was also intermediate to that of the control and clear-cut plots, although of course the vegetation occurred in discrete strips of uncut forest, and shrub-dominated cut strips.

The breeding bird census data are summarized in Table 3. Note that data for the three control plots and

TABLE 1—Characteristics of the uncut mixed-species hardwood forest where the census plots were located, based on five 20 × 20 m quadrats in each of the three control plots

Species	Density (trees/ha)	Basal area (m^2/ha)	Frequency (%)	Relative density (%)	Relative dominance (%)	Relative frequency (%)	Importance value[1]
Betula papyrifera	470	8.08	100	27.7	31.2	17.9	76.8
Acer rubrum	412	7.18	93	24.3	27.8	16.6	68.7
Acer saccharum	265	4.65	67	15.6	18.0	12.0	45.6
Betula allegheniensis	203	2.04	67	12.0	7.9	12.0	31.9
Fagus grandifolia[2]	50	0.24	60	2.9	0.9	10.7	14.5
Fraxinus americana	27	1.32	13	1.6	5.1	2.3	9.0
Other species	49	0.72	60	3.1	2.8	10.7	16.6
Dead trees	217	1.63	100	12.8	6.3	17.9	37.0
Total	1693	25.86	—	—	—	—	—

[1]Sum of relative density + relative dominance + relative frequency.
[2]Beech.

TABLE 2—Characteristics of the vegetation of the plots censused for breeding bird populations

Treatment	Plot number	Age (yr)	Plot area (ha)	Canopy height (m)	Tree density (stems/ha)	Stem basal area (m^2/ha)	Canopy cover (%)	Shrub density (stems/ha)	Ground cover (%)
Control	3	~70	3.3	19	1800	28.3	87	3 200	50
	6	~70	5.6	16	1400	19.7	73	7300	75
	8	~70	3.4	17	1900	29.6	77	2 400	60
Clear-cut	1	3	4.1	0	0	0	0	29 400	120
	7	3	3.4	0	0	0	0	23 600	100
	5	5	3.4	0	0	0	0	36 800	170
Thin	9	5	1.8	23	460	13.3	26	41 900	160
Narrow Strip-cut	2	4	6.2						
(a) Cut strips				0	0	0	0	40 600	160
(b) Uncut strips				19	1400	26.1	73	6200	100
Wider Strip-cut	4	4	2.9						
(a) Cut strips				0	0	0	0	29 200	180
(b) Uncut strips				16	1600	20.7	81	9 100	60

for the three clear-cut plots were reported in combined form elsewhere (Freedman et al. 1981). In terms of the total density of breeding birds, the three control plots (mean ± SD = 663 ± 145 pairs/km^2) fell near the middle of the range of densities for eight recent breeding bird censuses in maple or birch-dominated hardwood forests of the northeastern United States or eastern Canada (mean ± SD = 635 ± 328 pairs/km^2, range = 260–1200 from 1979 censuses reported in American Birds, Vol. 34, No. 1). The breeding bird community in the uncut forest was dominated by such species as Least Flycatcher, Hermit Thrush, Solitary Vireo, Red-eyed Vireo, and various wood warblers, including Black-and-white Warbler, Northern Parula, Black-throated Green Warbler, American Redstart, and Ovenbird (Table 3).

The total breeding bird densities of the clear-cut plots fell within the range of those of the control plots (mean ± SD = 588 ± 155 pairs/km^2). Species richness, however, averaged less (12.3 ± 3.5 species per control plot vs. 8.3 ± 1.5 species per clear-cut plot). In addition, there were great differences in species composition. In the clear-cut (low shrub) plots the community was dominated by Chestnut-sided Warbler, Common Yellowthroat, Dark-eyed Junco, White-throated Sparrow, and Song Sparrow.

The total density of the thinned plot was 550 pairs/km^2, which was within the range of densities of both the clear-cut and the control forest. The low richness of only seven species occurring on this plot may in part be an artifact of the small plot size. The thinned plot contained species that also occurred either in the control forests or the clear-cut plots, notably Least Flycatcher and Chestnut-sided Warbler.

The total breeding densities of the strip-cut plots were 475 pairs/km^2 for the narrower strip-cuts, and 575 pairs/km^2 for the wider strip-cuts. Both of these were lower than the mean total density observed for the control plots, although only the density for the narrow strip-cut fell below the range observed among the three control plots. Species richness of 10 and 13 species per plot was only slightly lower than that observed on the control plots. Similarly to the thinned plot, the bird species of the strip-cut plots included those dominant in either the control or clear-cut plots. Forest birds, such as Least Flycatcher, Red-eyed Vireo, Ovenbird, and American Redstart were present on the strip-cut plots, as were species typical of the clear-cuts, such as Chestnut-sided Warbler and Common Yellowthroat. We stress that, because of the small size of our plots, we only have reliable data for breeding birds that have relatively small territories. Other species that are characterized by larger territory size, such as woodpeckers or corvids, might also be affected by these forestry manipulations, but were not satisfactorily censused in our study.

Analysis of the total densities of birds among plots showed no significant heterogeneity (chi-square test, $P > 0.05$).

Only in one other study have the impacts of forestry operations on populations of breeding birds in northeastern hardwood forests been examined (Webb et al. 1977). These authors examined stands which had 0, 25, 50, 75, or 100% of the merchantable volume removed, and used counts of the numbers of singing males heard at permanent sampling points as an index of breeding bird abundance. Webb et al. (1977) observed no significant changes in breeding bird abundance. There were, however, changes in species composition on the various plots, the most notable of which was a decline in Ovenbird abundance in the 75% and 100% removal treatments.

In summary, we found few differences in the total

TABLE 3—Densities of breeding birds in plots variously affected by cutting practices in a mixed hardwood forest in Nova Scotia. Only species having at least 0.5 territorial pairs on a plot are indicated

	Density (pairs/km²)								
	Control plots			Clear-cut plots			Thinned plot	Strip-cut plots	
Species	3	6	8	1	7	5	9	2	4
Common Snipe	0	0	0	10	15	0	0	0	0
Ruby-throated Hummingbird	0	0	0	25	30	15	0	0	0
Alder Flycatcher	0	0	0	0	0	30	0	0	0
Least Flycatcher	290	120	0	0	0	0	140	60	100
Eastern Wood Pewee	0	10	0	0	0	0	0	0	0
Tree Swallow	0	0	0	10	0	0	0	0	0
American Robin	0	20	0	10	0	0	0	0	0
Hermit Thrush	60	40	30	0	0	0	0	15	0
Veery	50	10	0	25	0	0	0	15	0
Solitary Vireo	60	30	0	0	0	0	0	15	0
Red-eyed Vireo	80	50	30	0	0	0	80	30	70
Black-and-White Warbler	15	50	40	0	0	0	0	70	15
Northern Parula Warbler	15	30	40	0	0	0	0	10	40
Black-throated Blue Warbler	0	0	30	0	0	0	0	0	20
Black-throated Green Warbler	50	30	30	0	0	0	0	15	0
Chestnut-sided Warbler	0	0	0	100	40	190	110	50	70
Ovenbird	150	120	200	0	0	0	0	60	100
Northern Waterthrush	0	20	0	0	0	0	0	0	0
Mourning Warbler	0	0	0	0	0	90	80	20	0
Common Yellowthroat	0	0	0	25	300	130	80	0	50
American Redstart	15	80	100	0	0	0	30	90	90
Rusty Blackbird	0	0	0	0	30	0	0	0	0
Rose-breasted Grosbeak	15	10	0	0	0	0	0	0	0
Dark-eyed Junco	15	20	15	50	70	30	0	25	20
White-throated Sparrow	0	20	0	90	190	100	30	0	0
Song Sparrow	0	0	0	90	70	0	0	0	0
Total	815	660	515	435	745	585	550	475	575
Richness	12	16	9	10	8	7	7	13	10

density or richness of the breeding birds of a hardwood forest that was affected by several forestry practices, including clear-cutting, strip-cutting, and thining. However, there were marked species changes, with obligate forest birds being replaced by early successional species on the clear-cuts. The strip-cuts and thin, being intermediate in vegetation structure, also had intermediate mixtures of breeding birds.

Acknowledgments

We gratefully acknowledge the field assistance of J. Beckwith, J. Dale, A. Duinker, O. Maessen, S. Manuel, J. McLaren, and R. Morash. A. J. Erskine helped with the interpretation of some bird territories. Funding for this work was provided by a research grant to B. F. and I. A. M. from the Canadian National Sportsmen's Fund.

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Received 21 November 1980
Accepted 6 March 1981

APPENDIX 1—Scientific names of all bird species mentioned in the text

Common Snipe	*Capella gallinago*
Ruby-throated Hummingbird	*Archilochus colubris*
Alder Flycatcher	*Empidonax alnorum*
Least Flycatcher	*Empidonax minimus*
Eastern Wood Pewee	*Contopus virens*
Tree Swallow	*Iridoprocne bicolor*
American Robin	*Turdus migratorius*
Hermit Thrush	*Catharus guttatus*
Veery	*Catharus fuscescens*
Solitary Vireo	*Vireo solitarius*
Red-eyed Vireo	*Vireo olivaceous*
Black-and-white Warbler	*Mniiotilta varia*
Northern Parula Warbler	*Parula americana*
Black-throated Blue Warbler	*Dendroica caerulescens*
Black-throated Green Warbler	*Dendroica virens*
Chestnut-sided Warbler	*Dendroica pensylvancia*
Ovenbird	*Seiurus aurocapillus*
Northern Waterthrush	*Seiurus noveboracensis*
Mourning Warbler	*Oporornis philadelphia*
Common Yellowthroat	*Geothlypis trichas*
American Redstart	*Setophaga ruticilla*
Rusty Blackbird	*Euphagus carolinus*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Dark-eyed Junco	*Junco hyemalis*
White-throated Sparrow	*Zonotrichia albicollis*
Song Sparrow	*Melospiza melodia*

Breeding, Feeding, and Chick Growth of the Black Guillemot (*Cepphus grylle*) in Southern Quebec

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Cairns, David. 1981. Breeding, feeding, and chick growth of the Black Guillemot (*Cepphus grylle*) in southern Quebec. Canadian Field-Naturalist 95(3): 312–318.

Black Guillemots (*Cepphus grylle*) at a colony in the estuary of the St. Lawrence River bred about 3 wk earlier than those of another in the northeastern Gulf of St. Lawrence; mean hatching dates were 26 June and 15 July, respectively. Chicks spent a mean of 36.5 d in the nest in both colonies, and fledged at about 88% of adult weight. Four chicks were observed to fledge with no parental involvement. Chick diets consisted largely of blennies and other littoral fishes. The daily feeding rhythm was bimodal, with mid-morning and mid-afternoon peaks. Hatching and fledging rates per egg laid were much lower in single-egg nests than in two-egg nests. Chick mortality was highest during the first few days after hatching and affected first and second chicks equally.

Key Words: Black Guillemot, *Cepphus grylle*; breeding chronology, feeding, fledging, Gulf of St. Lawrence.

The Black Guillemot (*Cepphus grylle*) is a pursuit-diving sea bird of inshore arctic and northern Atlantic waters. Breeding sites are extensively distributed within this range, and most take the form of small loose colonies, although some birds nest solitarily, and some large arctic colonies are known (Brown et al. 1975).

Most currently available data on the life history of the Black Guillemot come from near the southern margin of its range, in the Bay of Fundy (Winn 1950; Preston 1968) and northeastern Denmark (Asbirk 1979 a, b). The colonies examined in these areas are limited in population by number and quality of nesting cavities, and are thus probably atypical of most guillemot breeding sites.

In the present paper I describe breeding chronologies, chick diets and growth rates, and patterns of nesting success in two eastern Canadian colonies. Breeding habitat was available in excess in both locations — a fact significant to breeding phenology and to the relation between habitat morphology and nesting success (Cairns 1980).

Study Area and Methods

This study was conducted on Brandypot Island (47°52′N, 69°41′W) in the St. Lawrence estuary, 21 April to 23 August 1976, and on the St. Mary's Islands (50°18′N, 59°39′W) in the northeastern Gulf of St. Lawrence, 6 May to 25 August 1977.

Brandypot Island lies roughly midway between the north and south banks of the St. Lawrence, at a point where the estuary is 27 km wide. Tidal amplitude in the area is about 5 m, and the brackish waters have a surface salinity of about 20 ‰ (Lavoie and Beaulieu 1971). Brandypot consists of three wooded islets underlain by quartzite and conglomerate, which are exposed at the shoreline as rocky slopes, cliffs, or boulder heaps. About 200 breeding pairs of Black Guillemots share the island with nesting Double-crested Cormorants (*Phalacrocorax auritus*), Great Blue Herons (*Ardea herodias*), Black-crowned Night Herons (*Nycticorax nycticorax*), Black Ducks (*Anas rubripes*), Common Eiders (*Somateria mollissima*), Great Black-backed Gulls (*Larus marinus*), Herring Gulls (*L. argentatus*), and Razorbills (*Alca torda*).

The four islands of the St. Mary's chain lie 11 km off the Quebec North Shore of the Gulf of St. Lawrence, in an area influenced by cold Labrador Current waters entering the Gulf through the Strait of Belle Isle. Tidal range in the area is about 1 m. Central parts of the islands are covered by low heath vegetation, but there are broad rocky slopes around their peripheries. West and Middle Islands, where the study was conducted, harbor about 145 breeding pairs of Black Guillemots. Red-throated Loons (*Gavia stellata*), Common Eiders, Great Black-backed Gulls, Herring Gulls, Common Terns (*Sterna hirundo*), Arctic Terns, (*S. paradisaea*), Razorbills, Common Murres (*Uria aalge*), and Atlantic Puffins (*Fratercula arctica*) also breed on these islands. Further physical and avifaunal details are given by Reed (1973) for Brandypot and by Bédard (1969) and Chapdelaine (1980) for the St. Mary's Islands.

Data on nesting success and chick growth rates were gathered during nest visits spaced 4–5 d apart on Brandypot, except for a small number of easily accessible nests which were checked daily. On St. Mary's, nests were visited daily in two high-density subcolonies, and at intervals of 4 d elsewhere.

Chicks were weighed with Pesola spring balances.

Chick diets were examined on Brandypot by collecting fish from the vicinity of the nests, and by constricting chicks' throats with pipe cleaners for periods of 3–6 h to prevent them from swallowing food items delivered by their parents. At St. Mary's, food items were identified and counted visually, and fledging behavior was observed, from a blind that gave a view of six active nests. Feeding and fledging times are given in Atlantic Standard Time.

Results

Breeding Phenology and Behavior

Black Guillemots were present in the waters around both study islands by the beginning of field work; I counted 400 around Brandypot on 26 April 1976, and 185 around St. Mary's on 8 May 1977. On Brandypot, birds were first observed on the rocks below the breeding sites on 25 April, with the first copulations recorded on 29 April. These events occurred over 2 wk later on St. Mary's where birds were first seen on land on 12 May, and the first copulation noted on 17 May.

Social interactions on the water were frequent during the prelaying period and most often took the form of pursuits. On Brandypot, the birds took part in massed communal flights, involving up to several hundred individuals and lasting several minutes. During these flights the guillemots often rose in tight formation up to about 150 m above the water.

After the first landings, the guillemots gradually spent more time on shore, and by the beginning of egg-laying the diurnal attendance patterns displayed through the remainder of the breeding season were established. On Brandypot, attendance was higher in the morning but peaked only at high tides, whereas on St. Mary's attendance peaked regularly in the early morning and late evening (Cairns 1979).

The nesting cycle was about 3 wk earlier on Brandypot than on St. Mary's (Figure 1); mean hatching dates were 26 June (n = 118) and 15 July (n = 111) in the two areas, respectively. The duration of the nestling period was similar at both sites and its combined mean was 36.5 d (SD = 1.5, n = 16, range 34–39).

Fledging of chicks was observed on four occasions at St. Mary's. All departures took place well after sunset, between 19:35 and 20:30. Chick exits were preceded by considerable movement within the nest cavity, which I could hear from the blind, and chicks were observed briefly at the nest entrance up to three times before their final departures. After leaving the nest, the fledglings made their way to the water 40 to 50 m away in bouts of scrambling and flapping that alternated with rest periods of up to 10 min. None of the fledglings was capable of sustained flight, and their flapping leaps usually carried them no more than 1 or 2 m.

On Brandypot most fledglings must have left the vicinity of the colony immediately after leaving the nest, because only two birds in juvenal plumage were ever seen on the water there. These birds probably dispersed towards the lower St. Lawrence estuary, because bands from four birds I had banded as chicks

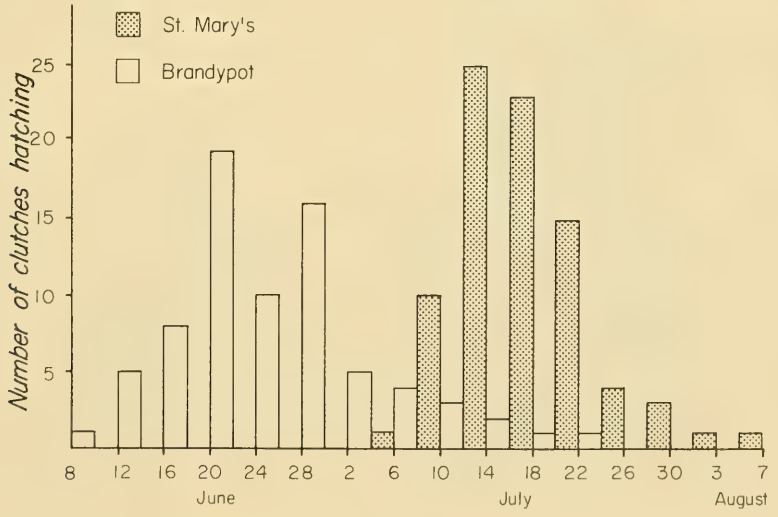

FIGURE 1. Black Guillemot hatching dates on Brandypot Island in the St. Lawrence estuary (1976) and on the St. Mary's Islands in the Gulf of St. Lawrence (1977).

TABLE 1—Food items delivered to Black Guillemot chicks

Prey	Brandypot		St. Mary's	
	No.	%	No.	%
Crustacea	—	—	2	1
Osmeridae				
Capelin (*Mallotus villosus*)	2	15	—	
Gadidae				
Atlantic Tomcod (*Microgadus tomcod*)	1	8	119	33
Ammodytidae				
American Sand Lance (*Ammodytes americanus*)	1	8	27	8
Blennioidea				
Rock Gunnel (*Pholis gunnellus*)	2	15		
Rock Gunnel/ Wrymouth (*Cryptacanthodes maculatus*)[a]			65	18
Arctic Shanny (*Stichaeus punctatus*)	—		101	28
Polar Eelpout (*Lycodes turneri*)	1	8	—	
Ocean Pout (*Macrozoarces americanus*)	3	23	—	
Unidentified	—		20	6
Cottidae				
Arctic Staghorn Sculpin (*Gymnocanthus tricuspis*)	1	8	—	
Grubby (*Myoxocephalus aeneus*)	1	8	—	
Mailed Sculpin (*Triglops murrayi*)	1	8	—	
Unidentified	—		28	8

[a]These species could not be reliably distinguished from the blind.

on Brandypot were returned from this area from late August to October 1976. Adult birds left the Brandypot area simultaneously with the young.

Postfledging dispersal of adults and young from St. Mary's had not begun by 26 August. Juvenile birds were regularly seen on the water after the onset of fledging, and no reduction in the number of adult birds in the area was noted during the fledging period.

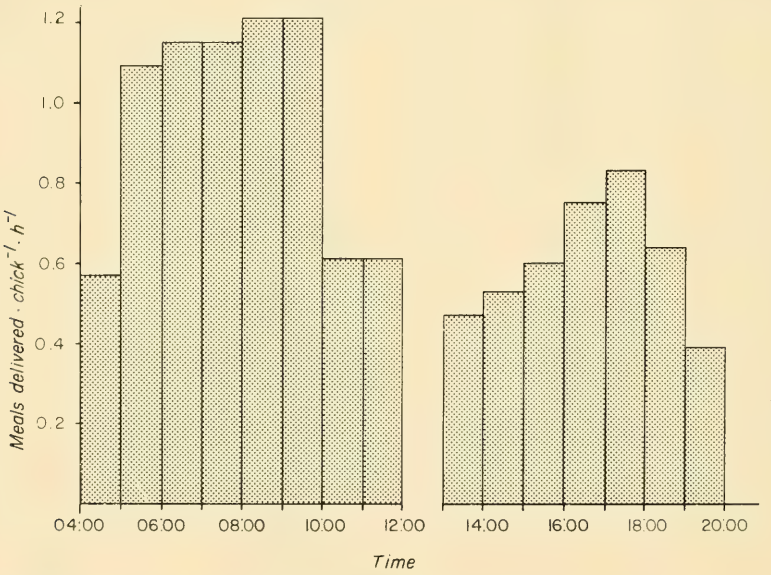

FIGURE 2. Daily rhythm of food deliveries to Black Guillemot chicks on St. Mary's, based on 20 to 36 chick-hours of observation for each hour. No observations available between 12:00 and 13:00.

Feeding of the Chick

Thirteen fish were collected from Black Guillemot nests at Brandypot. At St. Mary's 362 food deliveries to six nests were recorded during 51 h of observation between 2 and 17 August. Chicks in the observed nests were aged 11 d to fledging. Prey items observed or collected are listed in Table 1. All food loads that were clearly seen contained a single fish, except two on St. Mary's in which the prey appeared to be a shrimp-like crustacean. Eight percent of food deliveries on St. Mary's were not identified, but in most cases this was due to my attention being drawn by the simultaneous arrival of a food-carrying adult at another nest. It is therefore likely that most unidentified prey belonged to species observed at other times. About half the food items from both study areas were Blennioidea, small mainly benthic fishes. At St. Mary's, Atlantic Tomcod (*Microgadus tomcod*) and American Sand Lance (*Ammodytes americanus*) comprised most of the remainder of the sample.

Several of the guillemots in the St. Mary's feeding observation area were banded and could be distinguished from their mates, allowing the feeding patterns of individual birds to be monitored. A total of 127 food deliveries by eight recognizable birds was recorded. The frequency distributions of prey items delivered by these birds differed markedly ($P < 0.005$, G-test), which suggests that Black Guillemots have individual preferences either of prey species or of feeding area. One guillemot completely specialized in lance and was not observed to deliver any other prey ($n = 17$).

The daily rhythm of food deliveries on St. Mary's was bimodal with a strong peak in the morning and a lesser one in the afternoon (Figure 2). Rates of food delivery were 0.70 items·chick^{-1}·h^{-1} for two-chick broods, and 0.95 items·chick^{-1}·h^{-1} for singletons ($P<0.025$, G-test), with an overall rate of 0.79 items·chick^{-1}·h^{-1}.

Terns nested as close as a few metres from Black Guillemot sites on St. Mary's, as did gulls on both study islands. However, kleptoparasitism was infrequent, and of the four attacks I witnessed (all on St. Mary's), only one, by a Great Black-backed Gull, was successful.

Growth of the Chick

Weight curves for 23 chicks on Brandypot and 45 chicks on St. Mary's show that growth in both areas was similar (Figure 3). Because the chicks in most cases were not weighed daily, the individuals represented in each age-class varied from day to day. This variation in the sample content is likely responsible for most of the irregularity in the curves, particularly near fledging, when sample sizes were smallest.

Mean weights ±SD (n) of chicks measured within 24 h of fledging were 356 ± 10.6 g (7) at Brandypot

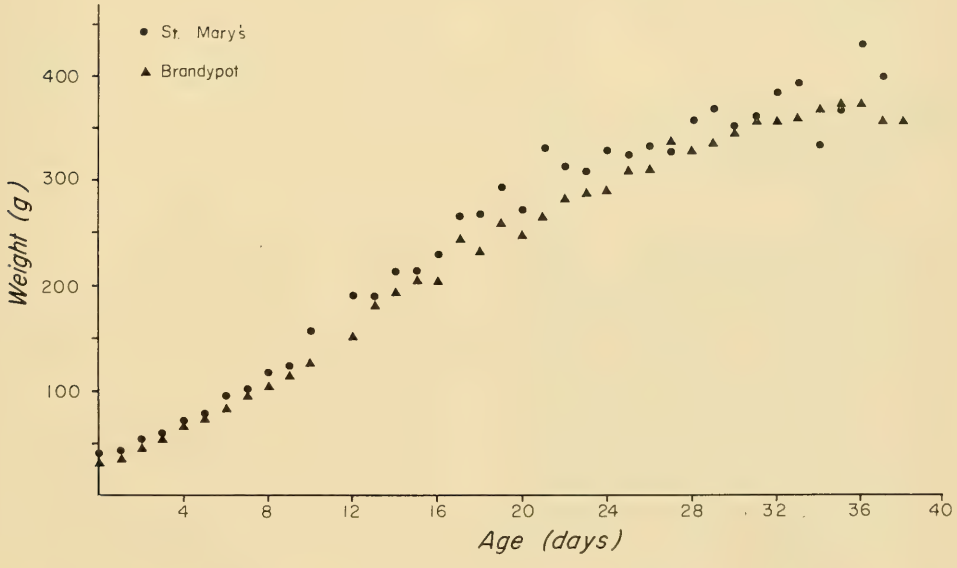

FIGURE 3. Growth in weight of Black Guillemot chicks. Number of chicks varied between 2 and 16 on Brandypot, and between 1 and 33 on St. Mary's.

TABLE 2—Black Guillemot nesting success for one-egg (25 nests) and two-egg (187 nests) clutches (data from both study areas). Differences tested by G-test (*$P < 0.05$; **$P < 0.01$).

	Clutch size	
	One-egg	Two-egg
Eggs hatched/nest	0.32	1.17
Eggs hatched/egg laid	0.32*	0.58*
Chicks fledged/nest	0.12	0.78
Chicks fledged/egg laid	0.12**	0.39**
Chicks fledged/chick hatched:		
one-chick broods	0.38(8)[a]	0.63(32)[a]
two-chick broods	—	0.67(93)

[a]Number of individuals in parentheses.

and 355 ± 23.8 g (13) at St. Mary's. Fledging weights were about 88% of breeding adult weights (401 ± 14.9 g (7) for Brandypot, 407 ± 31.8 (47) for St. Mary's).

Egg and Chick Survivorship

Mean clutch size was 1.88 in the 212 nests monitored (Table 2). Production from single-egg nests was reduced not only by the smaller number of eggs, but also through lowered hatching and fledging rates. Mean production from two-egg nests was 6.5 times greater than for one-egg nests.

Most chick mortality occurred during the first few days after hatching, and no deaths were recorded after 24 d (Figure 4). Chick mortality was unrelated to order of hatching: of 10 chicks found dead whose hatching sequence was known, five hatched first and five hatched second.

Discussion

The onset of breeding in sea birds is ultimately determined by annual cycles of water temperature and other oceanographic variables that control prey abundance (Immelmann 1971; Salomonsen 1955). These cycles only roughly correlate with atmospheric trends; thus the 1-mo lag in springtime air temperature curves between Brandypot and St. Mary's corresponds to a similar delay in guillemot nesting, although the guillemots of Kent Island in the Bay of Fundy also nest later than those of Brandypot, despite similar spring temperature regimes (Preston 1968; weather data from Rivière-du-Loup, Harrington Harbour, and Grand Manan show spring temperatures close to long-term means during study years, Atmostpheric Environment Service 1975, 1976–1977).

Despite their later breeding date, Kent Island guillemots first come to land at roughly the same time as Brandypot birds (Winn 1950; Preston 1968), presumably because early arrivals have a better chance of securing or retaining one of the colony's small number of good-quality nesting cavities.

The occurrence of massed communal flights on Brandypot Island is related to the fact that most of the birds there bred in high density along a single strip of straight coastline and were thus in visual contact with each other while on the water below the breeding sites. Such flights were not observed at St. Mary's nor at other colonies where guillemots breed in small subcolonies separated by headlands (Preston 1968; Bergman 1971; Asbirk 1979a, b). Massed high-altitude flights have rarely been reported for alcids, which normally fly low over the water (Tuck's (1961) record of Common Murre flights is an exception). Because such flights require a much greater energy expenditure than normal flying, they probably have a ritual function. Asbirk (1979b) speculated that communal gatherings of guillemots on the water play a role in establishing a social hierarchy that would determine proprietorship of nest sites, but this is unlikely to have been the case on Brandypot where sites were available in excess.

According to Winn (1950) and Thoresen and Booth (1958), the Black Guillemot and the closely related Pigeon Guillemot (*Cepphus columba*) lure their

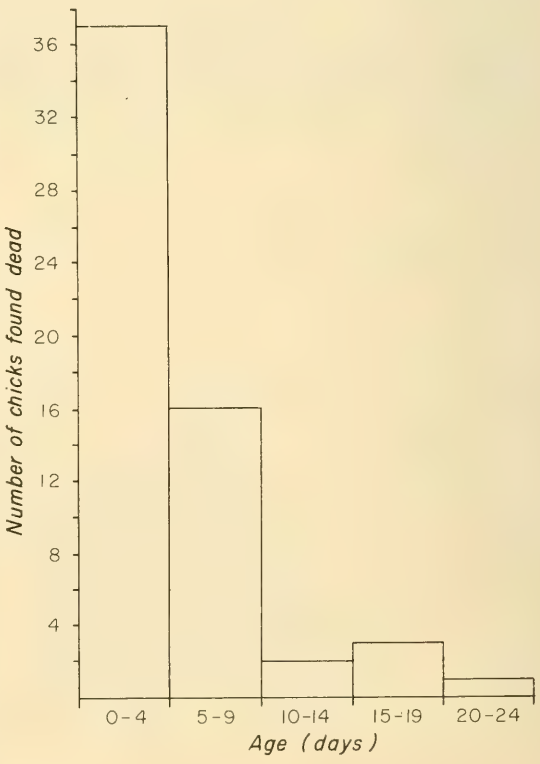

FIGURE 4. Age at death of Black Guillemot chicks (data from both study areas).

young from the nest by dangling a fish in front of the nest entrance. I observed no adult behavior that could be interpreted as an attempt to coax chicks from the nest. Moreover, my observations of fledgings occurred after the last feeding visits of the adults in the evening, and adults on three occasions were observed to bring fish to nests from which the young had already fledged.

The Black Guillemot is basically a littoral species and is seldom sighted far offshore (Brown et al. 1975). Although the adults feed on both fishes and invertebrates (Belopol'skii 1957; Uspenski 1958; Hartley and Fisher 1936), the young are fed almost exclusively on fish. Small benthic Blennioidea were the chief prey on Brandypot and St. Mary's, as they are in the Bay of Fundy (Winn 1950; Preston 1968), the Gulf of Finland (Bergman 1971), and Denmark (Asbirk 1979a).

Individual feeding specialization as found on St. Mary's has been previously documented by Slater and Slater (1972) for Black Guillemots and by Drent (1965) for Pigeon Guillemots. Although colony attendance patterns of Danish and St. Mary's guillemots are very similar (Asbirk 1979a; Cairns 1979), feeding rhythms differed markedly. The feeding rhythm at St. Mary's resembled the bimodal attendance pattern, but feeding in Denmark was relatively uniform throughout the day (Asbirk 1979a). Overall feeding rates were lower in Denmark (Asbirk 1979a) and higher in the Bay of Fundy (Preston 1968) than those found on St. Mary's but in the absence of reliable measures of meal weights, valid comparisons of food intake cannot be made.

Growth rates, fledging weights, and nestling periods of Brandypot and St. Mary's chicks were similar to those reported in the literature (Winn 1950; Bianki 1967; Belopol'skii 1957; Asbirk 1979a), although Asbirk (1979a) found a substantially longer nestling period (39.5 d vs. 36.5 d).

The normal clutch size of Black and Pigeon Guillemots is two eggs, although one-egg clutches are regularly encountered. Production per egg laid is markedly lower in one-egg nests than in two-egg nests (Preston 1968; this study), and the difference is due to depressed viability of both eggs and chicks. Because breeding success on Brandypot and St. Mary's was not related to habitat structure or nesting density (Cairns 1980), it can be inferred that production of single-egg clutches, with subsequent lowered hatching and fledging rates, is associated with couples of inferior parental quality. Asbirk (1979a) found single eggs to be laid more often in inexperienced breeders, and breeding success has been negatively linked to parental weights in several sea-bird species (e.g., Coulson 1968). Furthermore, any weakness of parental drive on the part of pairs that produced one-egg clutches could be exacerbated by the depressing effect of observer disturbance on breeding success (Cairns 1980).

Acknowledgments

This study was funded by grants from the National Research Council of Canada to J. Bédard, and by a Canadian Wildlife Service grant-in-aid of university research. G. Rochette provided invaluable field assistance on Brandypot, and prepared the figures. The Canadian Ministry of Transport generously permitted the use of their facilities for personal lodging on both Brandypot and St. Mary's. G. Foreman and L. Chislett, lightkeepers on St. Mary's Islands, provided advice, assistance, and warm hospitality during field work there. A. Cairns, W. Cairns, and D. N. Nettleship furnished useful advice during preparation of the manuscript.

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Received 23 June 1980
Accepted 16 March 1981

Food Habits of Deer Mice (*Peromyscus maniculatus*) in Northern Ontario

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Martell, Arthur M., and Ann L. Macaulay. 1981. Food habits of Deer Mice (*Peromyscus maniculatus*) in northern Ontario. Canadian Field-Naturalist 95(3): 319–324.

Summer (May–September) food habits of 712 Deer Mice (*Peromyscus maniculatus*) were examined on uncut, selectively cut, clear-cut, and recently burned sites near Manitouwadge, Ontario. Foods taken showed a distinct seasonal pattern. The number of food items taken was much lower in May and June than later in the summer. The major food items in May–June (arthropods and seeds) and in July–September (arthropods, seeds, and berries) varied in amount taken among the sites and was likely a reflection of their availability. The diet of Deer Mice in selectively cut stands was highly similar to that in both clear-cuts and recent burns. Deer Mice, because of the diversity and the plasticity of their diet, are able to exploit successfully the limited food resources available on disturbed and successional sites.

Key Words: Deer Mice, *Peromyscus maniculatus*; food habits, diet, clear-cut, burn.

Deer Mice (*Peromyscus maniculatus*) are rare in uncut upland Black Spruce (*Picea mariana*) – Feather Moss (*Pleurozium schreberi*) forests in northern Ontario. After those forests are clear-cut, Deer Mice invade from adjoining mixed wood stands and predominate in the small mammal community by the end of the second summer following harvest (Martell and Radvanyi 1977; Martell, unpublished data). They maintain that status for at least 15–25 yr following harvest. Deer Mice are also common on recent burns.

Deer Mice, through their seed-feeding activities, have been considered a serious hindrance to regeneration of forests in many parts of North America (see Pank 1974). Because of the major ecological changes caused by timber harvesting and subsequent scarification, the availability of preferred foods on clear-cuts may be altered drastically. However, few researchers have examined the changes in food habits of Deer Mice on clear-cuts or in the ensuing successional stages (Schloyer 1976).

As part of an investigation of the role of small mammals in the regeneration of upland Black Spruce forests in northern Ontario, we examined the food habits of Deer Mice on clear-cuts, on recent burns, and in uncut and selectively cut stands. The primary aim of the study was to determine if Deer Mice consume significant quantities of Black Spruce seeds, but we also hoped that an examination of food habits would help explain why Deer Mice are so successful at exploting recent clear-cuts and burns while other species, such as the Southern Red-backed Vole (*Clethrionomys gapperi*), show a drastic decline in numbers following harvest.

Study Area and Methods

The study area was located on the Ontario Paper Company lease near Manitouwadge, Ontario (49°07′N, 85°50′W). Before harvest, upland sites supported mature stands of Black Spruce – Feather Moss forest. After clear-cutting and subsequent scarification with small flanged barrels and spiked anchor chains, the sites consisted of exposed peat, mineral soil, and rock, with an extensive cover of slash, logs and stumps. Only a few small patches of living plants remained (< 5% cover). Vegetation cover increased with time (after 5 yr 7% moss and lichen cover and 30% vascular plant cover; after 12 yr 22% moss and lichen cover and 67% vascular plant cover). Recovery of vegetation on burns was more rapid than on clear-cuts. Dry knolls in the study area supported mixed stands of Trembling Aspen (*Populus tremuloides*), Paper Birch (*Betula papyrifera*), White Spruce (*Picea glauca*), and Balsam Fir (*Abies balsamea*). The conifers were selectively harvested from many of those stands leaving the aspen, Paper Birch, young conifers, and the thick shrub and herb layer. Patches of unharvested mixed wood occurred throughout the selectively harvested stands.

Deer mice were taken with snap traps set in pairs at approximately 15-m spacing either in a single line (375 m long) or in a grid (approximately 2 ha in area). Traps were run for 72 h and were checked each 24 h. The following sites were sampled during the summers of 1976 and 1977: (A) uncut upland Black Spruce (2694 trap nights), (B) selectively cut mixed wood (4344 trap nights), (C) upland Black Spruce clear-cut during the winter of 1975–1976 (8058 trap nights), (D)

upland Black Spruce clear-cut during the winter of 1972–1973 (6096 trap nights), (E) upland Black Spruce clear-cut during the winter of 1965–1966 (3888 trap nights), (F) selectively cut mixed wood harvested and burned during early summer 1977 (300 trap nights), (G) upland Black Spruce clear-cut and burned during the summer of 1975 (1164 trap nights).

Stomachs were removed and the contents were treated by the method outlined by Williams (1959). The contents were washed through a 0.25-mm sieve with hot water to remove fat and gastric juice and were then dried on filter paper and stored in envelopes for further study. Before examination the contents were soaked in water in a watch glass for a few minutes to restore their original appearance. The contents were then examined under a dissecting microscope at 20–30 × and the volume of each food item was estimated to the nearest 5%. Identification of items was made by comparison with a reference collection made on the study area and by feeding known foods to captive animals and later examining their stomach contents. Seeds and fruits were identified with the aid of Montgomery (1977) and spores of hypogeous fungi were identified by J. M. Trappe, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oregon 97330.

In most cases seeds and berries could be identified to species. Although finely masticated seed endosperm was included with seeds, some were from berry seeds that were cracked open. No attempt was made to identify arthropods, epigeous fungi, or chlorophyllous plant matter to species. Stones, fragments of peat, and hair were not considered food items and were not included in the analysis. Food habits between sites were compared by percentage similarity (Pielou 1975).

Results and Discussion

Five mouse stomachs from uncut Black Spruce stands, 187 stomachs from selectively cut stands, 335 stomachs from clear-cuts, and 185 stomachs from burns were examined. Because only five stomachs were obtained from uncut Black Spruce stands, because the contents of those stomachs were not conspicuously different from the contents of stomachs taken at the same time in selectively cut stands, and because most of the selectively cut stands contained patches of uncut mixed wood, the five stomachs from uncut Black Spruce stands were combined with those from selectively cut stands.

Food habits showed a distinct seasonal pattern which was, in general, common to all sites (Figure 1). Arthropods were extremely important from May through early July and were less important later in the summer. Seeds were most important in early May and in September, while berries were important from early July through early September. The pattern is similar to that observed by Dyke (1971) for Deer Mice in

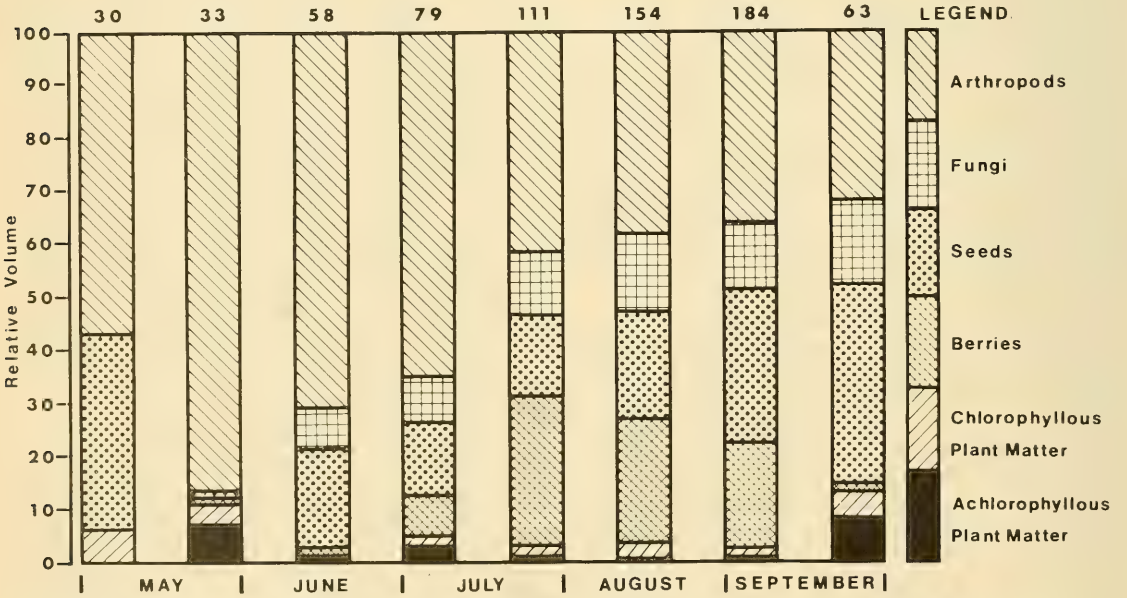

FIGURE 1. Seasonal pattern in summer foods of Deer Mice in northern Ontario. Samples sizes are given above the bars.

uncut boreal forest near Great Slave Lake, Northwest Territories.

The number of food items taken was much lower in May and June ($\bar{x}$ = 9.7 items) than later in the summer ($\bar{x}$ = 19.6 items). The mean percentage similarity for May–June was 67% and for July–September was 71%, but the two periods were only 57% similar to each other. Food habits were, therefore, combined into those two periods for comparison among areas. In the May–June period, sample sizes in three of the areas are so small that some food items may have been missed (Obrtel and Holisova 1977), but sample size was not a problem in the July–September period.

Although the major dietary items were similar in all habitats, there were marked differences among areas in the proportions of items taken both in early summer (Table 1) and in late summer (Table 2). In early summer arthropods made up most (> 70%) of the diet of Deer Mice on the 1975–1976 and 1965–1966 clear-cuts and on the 1977 burn, while arthropods and seeds made up most of the diet on other sites. The average percentage similarity was 77% within the first group, 64% within the second group, and 64% between groups. Seeds of graminoids predominated in the selectively cut stands and on the 1972–1973 clear-cut while seeds of Pink Corydalis (*Corydalis sempervirens*) predominated on the 1975 burn. There was no consistent pattern of change in any food item with age of either clear-cuts or burns. Deer Mice likely used whatever was available on the sites.

In late summer, arthropods and berries made up most (>65%) of the diet on the older (1972–1973 and 1965–1966) clear-cuts while arthropods and seeds made up most of the diet on other sites. The average percentage similarity was 62% within the first group, 69% within the second group, and 55% between groups. Seeds of graminoids predominated in the selectively cut stands and on the 1977 burn while seeds of Pink Corydalis predominated on the 1975–1976 clear-cut and on the 1975 burn. Blueberries (*Vaccinium angustifolium*) were the most important berries taken by Deer Mice. Consumption of blueberries increased with age of both clear-cuts and burns and was likely related to availability.

The high proportion of arthropods taken by Deer Mice in the present study is consistent with other studies. Arthropods have been reported to be an important component of the summer diet of Deer Mice in uncut forests in the Northwest Territories (48%) (Dyke 1971), Quebec (35%) (Hamilton and Hamilton 1954), and northeastern United States (71%) (Hamilton 1941). Williams (1959), however, examined the food habits of Deer Mice taken primarily in August in uncut forest in Wyoming and Colorado and found that arthropods made up only 13% of the diet, while seeds (primarily conifer seeds) made up 63%. Conifer seeds were not identified as food items in the present study. It is unlikely that anything but a rare occurrence was missed as we had no difficulty identifying conifer seeds in the stomach contents of Deer Mice kept in the laboratory and fed small quantities of seeds.

Few studies have been conducted on the changes in food habits of Deer Mice on clear-cuts. Tevis (1956) reported that the frequency of insects in the diet of Deer Mice in northwestern California was higher in cutover stands (60%) than in uncut stands (44%). Schloyer (1976) found that Deer Mice in West Virginia ate more invertebrates (> 45% volume) in very young (< 5 yr) clear-cuts and in mature forests (> 25 yr old) than in clear-cuts in the intermediate stages (30% volume). He suggests that the proportions consumed are related to the abundance of insects on those sites. In our study, the proportion of the late summer diet made up of arthropods was lower on young clear-cuts (36%) than in selectively cut stands (53%), and was lowest on the 11- to 12-yr-old clear-cut (20%). Those results are consistent with Schloyer's findings and may also be related to the availability of arthropods.

In general, there was a high degree of similarity between the diet of Deer Mice in selectively cut stands and that in both clear-cuts (65%) and burns (68%). The major dietary items differ more in proportion taken than in kind. Many of the differences are likely due more to variability among sites than to site treatment or age. Deer Mice, because of the diversity of their diet, appear able to exploit successfully the food resources available on disturbed and successional sites. Southern Red-backed Voles, on the other hand, have a more limited diet and appear dependent on food items which are scarce or absent on those sites (Martell 1981).

Our observed absence of conifer seeds in the diet of Deer Mice supports other studies which suggest that conifer seed predation is minimal on recent upland Black Spruce clear-cuts (Martell and Merritt 1979) and that Deer Mice do not actively search for Black Spruce seeds or Jack Pine (*Pinus banksiana*) seeds but, rather, encounter them by chance during a search for other foods (Martell 1979). Black Spruce seeds were available in uncut Black Spruce stands, White Spruce seeds were available in selectively cut mixed wood stands, and both Black Spruce seeds and Jack Pine seeds were available on the clear-cuts and burns. Also, Southern Red-backed Voles on the same sites consumed small quantities of conifer seeds (Martell 1981). Therefore, based on summer food habits, Deer Mice cannot be considered to be a serious predator of conifer seeds on upland Black Spruce clear-cuts in northern Ontario.

TABLE 1– May-June food habits of Deer Mice in northern Ontario. Relative volume (percent) and frequency of occurrence (in parentheses) of food items are presented

Food item	A and B	C	D	E	F	G
		Clear-cut			Burn	
	Uncut and selectively cut $n = 12$	1975–1976, $n = 35$	1972–1973, $n = 21$	1965–1966, $n = 7$	1977, $n = 8$	1975 $n = 38$
Arthropods	62.3(100)	87.0(100)	53.9(90)	71.4(71)	100.0(100)	63.2(90)
Fungi	—	—	—	—	—	12.0
Glomus spp.	—	—	—	—	—	10.9(37)
Unidentified macrofungi	—	—	—	—	—	1.1(3)
Seeds	21.7	8.9	40.0	—	—	21.3
Graminoids	15.0(17)	1.5(9)	39.8(57)	—	—	—
Corydalis sempervirens	—	3.4(6)	0.2(5)	—	—	20.4(40)
Unidentified seeds	—	4.0(6)	—	—	—	0.6(13)
Seed endosperm	6.7(17)	—	—	—	—	0.3(3)
Berries	—	—	1.2	—	—	2.8
Rosa acicularis	—	—	—	—	—	1.1(3)
Unidentified pulp	—	—	1.2(10)	—	—	1.7(5)
Chlorophyllous plant matter	10.1	2.1	—	14.2	—	1.0
Lichens	—	1.8(17)	—	—	—	0.2(5)
Mosses	—	0.3(3)	—	—	—	0.1(5)
Forbs and grasses	9.7(33)	—	—	7.1(14)	—	0.7(5)
Stamens and anthers	0.4(8)	—	—	7.1(14)	—	—
Achlorophyllous plant matter	6.3(17)	2.1(3)	4.8(10)	14.3(29)	—	0.1(3)

TABLE 2—July–September food habits of Deer Mice in northern Ontario. Relative volume (percent) and frequency of occurrence (in parentheses) of food items are presented

Food item	A and B	C	D	E	F	G
		Clear-cut			Burn	
	Uncut and selectively cut n = 180	1975–1976, n = 61	1972–1973, n = 153	1965–1966, n = 58	1977, n = 19	1975 n = 120
Arthropods	53.4(92)	37.3(85)	35.0(93)	19.7(74)	66.0(95)	38.4(89)
Fungi	9.5	5.8	17.8	7.2	12.7	15.7
Glomus spp.	8.2(45)	3.9(25)	16.8(59)	3.9(31)	10.6(37)	14.1(49)
Unidentified macrofungi	1.3(3)	1.9(8)	1.0(3)	3.3(7)	2.1(10)	1.6(3)
Seeds	22.1	43.0	14.0	13.4	18.7	29.8
Graminoids	10.4(21)	6.4(13)	9.6(27)	5.0(16)	10.0(37)	7.4(17)
Carex sp.	—	—	—	—	—	0.7(1)
Betula papyrifera	1.1(3)	—	—	—	—	—
Corydalis sempervirens	1.5(6)	25.1(49)	0.4(2)	—	—	9.9(2)
Potentilla (norvegica?)	0.1(1)	—	<0.1(1)	—	—	—
Aralia spp.	0.4(2)	—	—	0.1(2)	—	—
Epigea repens	—	—	—	3.7(12)	—	—
Unidentified seeds	2.1(7)	1.7(10)	1.3(8)	<0.1(2)	5.8(42)	1.3(16)
Seed endosperm	6.5(18)	9.8(16)	2.7(8)	4.6(17)	2.9(10)	10.5(23)
Berries	7.4	9.1	30.1	56.8	1.0	12.3
Comandra livida	0.1(1)	—	—	—	—	—
Ribes lacustre	0.4(2)	—	—	—	—	—
Fragaria virginiana	0.5(4)	1.1(3)	0.2(1)	1.2(9)	—	<0.1(1)
Rubus strigosus	1.8(13)	—	3.3(18)	1.3(12)	—	—
Rosa acicularis	—	—	0.5(1)	—	—	—
Vaccinium angustifolium	1.7(5)	7.0(26)	23.7(56)	52.1(81)	—	10.8(44)
Vaccinium myrtilloides	<0.1(1)	0.5(2)	0.2(3)	0.4(2)	—	—
Unidentified pulp	2.9(12)	0.5(3)	2.2(14)	1.8(7)	1.0(5)	1.5(7)
Chlorophyllous plant matter	3.0	3.8	2.0	1.1	0.3	1.4
Lichens	0.4(7)	—	0.6(15)	—	—	0.1(3)
Mosses	0.3(7)	0.3(3)	0.2(4)	0.3(7)	<0.1(5)	0.2(3)
Forbs and grasses	1.0(9)	2.2(10)	0.3(3)	0.3(2)	0.3(5)	0.4(4)
Stamens and anthers	1.3(13)	1.3(12)	0.9(16)	0.5(16)	—	0.7(10)
Achlorophyllous plant matter	4.7(12)	1.3(15)	1.2(9)	1.3(9)	1.3(10)	1.9(13)

Acknowledgments

We are grateful to Great Lakes Forest Research Centre, Ontario Ministry of Natural Resources, and Ontario Paper Company for their cooperation. We thank D. R. Fillman for preparing Figure 1, and J. E. Bryant and T. C. Dauphine for reviewing the manuscript.

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Received 5 January 1981
Accepted 6 April 1981

Food Habits of Southern Red-backed Voles (*Clethrionomys gapperi*) in Northern Ontario

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Summer (May–September) food habits of 258 Southern Red-backed Voles (*Clethrionomys gapperi*) were examined on uncut, selectively cut, and clear-cut sites near Manitouwadge, Ontario. Foods taken showed a distinct seasonal pattern with new green vegetation, seeds, berries, and mushrooms appearing in the diet as they became available. Conifer seeds were an insignificant part of the diet. The major dietary items, lichens and fungi, were common to all sites. Because environmental conditions on clear-cuts are unsuitable for those foods, Southern Red-backed Voles on clear-cuts are likely dependent on a declining food source.

Key Words: Southern Red-backed Vole, *Clethrionomys gapperi,* diet, food habits, clear-cut.

Southern Red-backed Voles (*Clethrionomys gapperi*) are common in uncut conifer and mixed wood forests in northern Ontario. When upland Black Spruce (*Picea mariana*) – Feather Moss (*Pleurozium schreberi*) forests are clear-cut, *C. gapperi* decline in numbers until they are rare or absent by the end of the second or third summer following harvest (Martell and Radvanyi 1977; Martell, unpublished data). The scarcity of red-backed voles on clear-cuts has been observed in other parts of North America and has been attributed to a decrease in either cover, or food supply, or both (Gashwiler 1970; Lovejoy 1975). However, comparative studies of food habits of red-backed voles in uncut and clear-cut stands are few (Schloyer 1977).

As part of an investigation of the role of small mammals in the regeneration of upland Black Spruce forests in northern Ontario, I examined the food habits of *C. gapperi* on clear-cuts and in uncut and selectively cut stands. The primary aim of the study was to determine if *C. gapperi* consume significant quantities of Black Spruce seeds, but I also hoped that an examination of food habits would help explain the decline in numbers of *C. gapperi* on clear-cuts.

Study Area and Methods

The study area was located on the Ontario Paper Company lease near Manitouwadge, Ontario (49°07′N, 85°50′W). Before harvest, upland sites supported mature stands of Black Spruce – Feather Moss forest. After clear-cutting and subsequent scarification only a few small patches of living plants remained. Dry knolls supported mixed wood stands from which the conifers were selectively harvested.

Southern Red-backed Voles were taken with snap traps during the summers of 1976 and 1977 in uncut upland Black Spruce (2694 trap nights), selectively cut mixed wood (4344 trap nights), upland Black Spruce clear-cut during the winter of 1975–1976 (8058 trap nights), and upland Black Spruce clear-cut during the winter of 1976–1977 (1884 trap nights). Vole stomachs were removed and the contents were treated by the method outlined by Williams (1959). A total of 44 stomachs from uncut stands, 141 stomachs from selectively cut stands, and 73 stomachs from clear-cuts were examined; 66 of the stomachs from clear-cuts were from the first summer after harvest and the remaining 7 were from the second summer after harvest. Because the food items were so finely masticated it was difficult to make specific identifications; however, food items could be placed in categories with more confidence. Stones, fragments of peat, and hair were not considered food items and were not included in the analysis. All of those items together, however, made up only 0.2% by volume of total stomach contents.

A more detailed description of the study area, of trapping methods, and of the analysis of the stomach contents is given by Martell and Macaulay (1981).

Results and Discussion

Food habits showed a distinct seasonal pattern which was similar in all stands (Figure 1). Lichens, mainly *Cladina* spp. and *Cladonia* spp., dominated the diet in early May and remained an important part of the diet throughout the summer. Fresh green plant matter was taken primarily between mid-May and mid-July as it became available. Green plant matter became available earlier on the uncut and selectively cut sites than on the clear-cuts. Seeds were taken primarily in June and early July, followed by berries in late July. Mushrooms grew in importance from

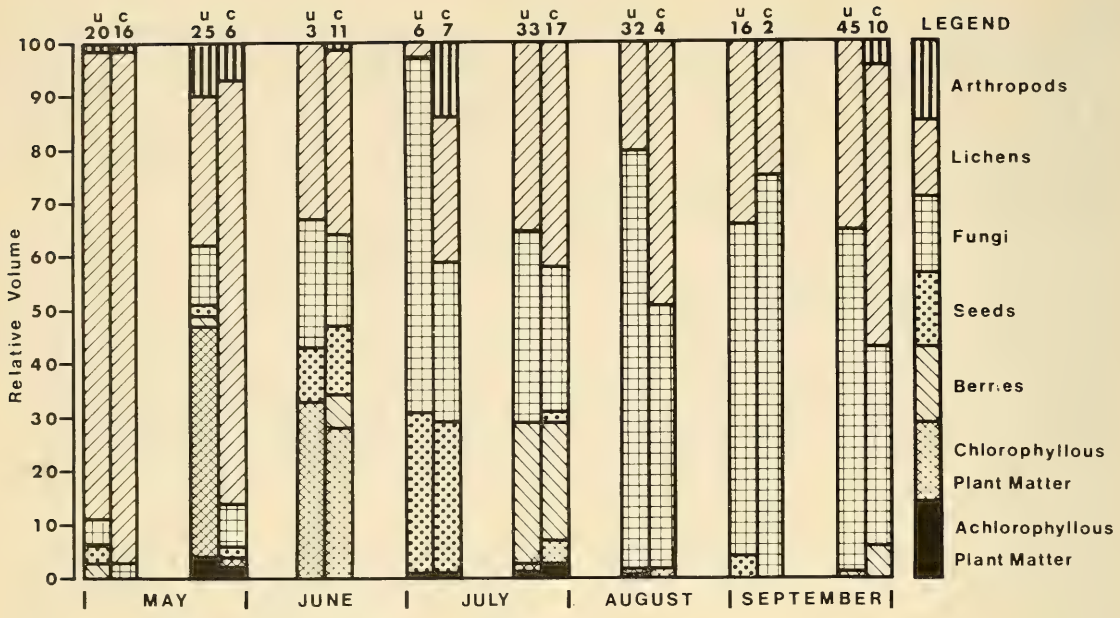

FIGURE 1. Seasonal pattern in summer foods of Southern Red-backed Voles in northern Ontario. Uncut Black Spruce stands are combined with selectively cut mixed wood stands to achieve sufficient sample sizes, and the combined sample (U) is compared with clear-cut upland Black Spruce stands (C). Sample sizes are given above the bars.

early summer until they were one of the primary food items in August and September. The pattern is similar to that reported for *C. gapperi* in conifer forest in the Northwest Territories (Dyke 1971) and in Manitoba (Perrin 1979).

Food habits were averaged over the summer to examine differences among sites (Table 1). Voles in uncut stands took much less arthropod material, berry material, and chlorophyllous plant matter, and much more achlorophyllous plant matter than voles in other stands. That may be related in part to availability, but is also influenced by the distribution of stomachs sampled; most of the stomachs from uncut stands were taken in early May and late September, whereas stomachs from the other stands were more evenly distributed throughout the summer. Voles in selectively cut stands took much less lichen and much more fungi than voles in either uncut or clear-cut stands. That difference is likely related to availability. In general, foods taken on clear-cuts were little different from those in uncut and selectively cut stands. Lichens and fungi made up most (80–89%) of the diet in all stands.

Schloyer (1977) examined the food habits of 139 *C. gapperi* on clear-cuts in West Virginia ranging in age from less than 1 yr to more than 25 yr after harvest. In that mixed deciduous forest *C. gapperi* did not disappear from clear-cuts after harvest as they did in northern Ontario. Schloyer found that the primary summer food items, by volume, were vascular plant matter (76%) and fungi (22%), primarily hypogeous fungi (19%), with no significant variation among ages of clear-cut. Insects made up only a small part of the diet (1%) but were significantly higher in the 16- to 20-yr successional stage (7%) than in the other stages. The food habits I observed were similar to those found by Schloyer (1977), except that most of the fungi consumed were epigeous (mushrooms) rather than hypogeous (*Glomus* spp.).

Summer (May–September) food habits of *C. gapperi* in conifer forest have been examined in the Northwest Territories (Dyke 1971), Colorado (Merritt and Merritt 1978), Manitoba (Perrin 1979), and Ontario (present study). Fungi were the most important food item in all studies except Manitoba; however, the absence of mushrooms in that study may have been due to the technique used to determine food habits. The proportions of other food items taken varied considerably among areas. Other major foods taken were berries in the Northwest Territories, green dicotyledonous vegetation and berry seeds in Manitoba, and lichens in the present study. Winter foods

TABLE 1—Summer (May–September) food habits of Southern Red-backed Voles in northern Ontario. Relative volume (percent) and frequency of occurrence (in parentheses) of food items are presented

Food item	Uncut Black Spruce, $n = 44$	Selectively cut mixed wood, $n = 141$	Clear-cut Black Spruce, $n = 73$
Arthropods	0.7 (30)	2.0 (34)	3.1 (44)
Lichens	58.6 (91)	30.1 (86)	56.4 (92)
Fungi	30.6 (55)	52.6 (82)	23.1 (53)
Unidentified mushrooms	30.1 (50)	47.9 (72)	22.2 (49)
Glomus spp. (spores)	0.5 (7)	4.7 (24)	0.8 (11)
Seeds	2.4 (25)	2.2 (18)	3.2 (32)
Conifer seed coats	<0.1 (2)	<0.1 (3)	0.1 (11)
Unidentified seed coats	<0.1 (2)	<0.1 (1)	—
Seed endosperm	2.4 (23)	2.2 (15)	3.1 (29)
Berries	2.8 (14)	6.1 (12)	7.4 (26)
Fragaria virginiana	—	0.2 (1)	—
Rubus pubescens	—	1.7 (5)	—
Vaccinium angustifolium	0.3 (9)	—	4.0 (12)
Rosa acicularis	—	—	0.6 (1)
Unidentified pulp	2.5 (5)	4.3 (7)	2.9 (12)
Chlorophyllous plant matter	3.2 (5)	8.6 (20)	6.8 (22)
Anchlorophyllous plant matter	2.4 (18)	0.5 (16)	1.1 (25)

also varied among areas with most of the winter diet being lichens and berries in the Northwest Territories (Dyke 1971), seeds and fungi in Colorado (Merritt and Merritt 1978), and dead dicotyledonous vegetation in Manitoba (Perrin 1979). Because essentially all of the major food items taken were present in the diet in all areas, the great differences among areas suggest that *C. gapperi* can adapt to the foods available. However, the similarity in food habits between uncut and clear-cut stands (Schloyer 1977, present study) suggests that this adaption does not take place rapidly.

On clear-cuts in northern Ontario, *C. gapperi* continued to use lichens and fungi as the major items of their diet. Freshly scarified upland Black Spruce clear-cuts are usually quite dry and undergo great fluctuations in daily temperature. Those conditions make clear-cuts unsuitable for mushrooms and lichens. Therefore, *C. gapperi* are likely feeding on a declining food source. Maser et al. (1978) note the importance of fungi to several species of red-backed voles and suggest that the reason California Red-backed Voles (*C. californicus*) disappear from clear-cuts within a year after logging and burning is that the voles are left without their specialized food supply, hypogeous fungi. The disappearance of *C. gapperi* following harvest in northern Ontario may also be related to a diminishing specialized food supply, as well as to a marked decrease in vegetative cover.

Conifer, primarily Black Spruce, seeds were taken more frequently on clear-cuts than in uncut and selectively cut stands, but conifer seeds were likely more abundant on clear-cuts than in uncut stands because cones in the slash open on the warm, dry clear-cuts and release their seeds. Conifer seeds, however, made up an insignificant part of the diet. This supports other studies which suggest that conifer seed predation is minimal on those recent clear-cuts (Martell and Merritt 1979) and that *C. gapperi* do not actively search for Black Spruce seeds or Jack Pine (*Pinus banksiana*) seeds but, rather, encounter them by chance during a search for other foods (Martell 1979). Based on their summer food habits and their rapid decline in numbers following clear-cutting, *C. gapperi* cannot be considered to be a serious predator of conifer seeds on upland Black Spruce clear-cuts in northern Ontario.

Acknowledgments

I am grateful to Great Lakes Forest Research Centre, Ontario Ministry of Natural Resources, and Ontario Paper Company for their cooperation. I thank A. L. Macaulay for assistance in the field, S. M. Martell for assistance in the laboratory, D. R. Fillman for preparing Figure 1, and J. E. Bryant and T. C. Dauphine for reviewing the manuscript.

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Received 5 January 1981
Accepted 6 April 1981

The Biological Flora of Canada

2. *Vaccinium myrtilloides* Michx., Velvet-leaf Blueberry*

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Vander Kloet, S. P., and I. V. Hall. 1981. The biological flora. 2. *Vaccinium myrtilloides* Michx., Velvet-leaf Blueberry. Canadian Field-Naturalist 95(3): 329–345.

Vaccinium myrtilloides Michx. is a deciduous low shrub endemic to North America with a range extending from central Labrador to Vancouver Island and from the Northwest Territories (61°N) to West Virginia (39°N). To produce fruit the flowers require cross-pollination by bees or andrenids. The fruit of *V. myrtilloides* is edible and matures during July and August. Only in New Brunswick and Maine does the species occur in commercially viable quantity on the blueberry barrens.

Key Words: *Vaccinium myrtilloides*, Velvet-leaf Blueberry; Sourtop Blueberry, biology, ecology, physiology, distribution, economic importance.

1. *Name*

Vaccinium myrtilloides Michaux; section *Cyanococcus*; Ericaceae;
V. canadense Richardson in Franklin's Journal (1823 p. 736);
V. angustifolium var. *integrifolium* Lepage 1951;
Sour-top Blueberry, Velvet-leaf Blueberry, Airelle du Canada (Marie-Victorin 1935), Airelle Fausse-Myrtille (Marie-Victorin 1964).

2. *Description of the Mature Plant*

(a) Raunkiaer life-form. Chamaephyte, rarely a nanophanerophyte. Although both Scoggan (1950) and LeBlanc (1963) list this species as a nanophanerophyte for Bic, Gaspé, and Mount Yamaska, respectively, the average height for *V. myrtilloides* is less than 50 cm (Camp 1945; Vander Kloet 1977) and we think their classification reflects the potential rather than the actual height of the species. Winter-deciduous, broad-leaved, low, colonial shrub with ascending branches, edible blue fruits, and deep tap root; reproduces by seeds and rhizomes.

(b) Shoot morphology. Stems woody, average height 25 cm with a maximum of 75 cm, usually densely pubescent (Figure 1C), occasionally pilose, verrucose, terete, bark dirty brown or green; buds of two types, the larger flower buds are borne terminally, and the more lanceolate vegetative buds, whose bracts are sharply acuminate (Figure 1D), are borne proximally; leaves alternate in a spiral, simple, pinnately netted, entire, elliptic, blade green and pubescent, rarely glabrous (Figure 1C); rhizomes woody, covered with a brown bark, bearing numerous shoots and adventitious roots; new rhizome growth white or pinkish. Rhizomes have a prominent central whitish pith when cut horizontally as opposed to the solid core of roots.

(c) Root morphology. The radicle of the seedling develops into an extensive tap root system (Hall 1957); the root system is finely divided at the extremities and like many closely related genera and species are devoid of any root hairs and protected by a root sheath (Leiser 1968).

(d) Inflorescence. The members of *Vaccinium* section *Cyanococcus* are characterized in part by flowers borne in racemes; members of section *Myrtillus* by contrast have flowers borne singly in the leaf axils. Flowers of *V. myrtilloides* (Figure 1B) are pentacyclic with five green sepals, five petals fused into a short urceolate, white to pink corolla, 4 ± 1 mm long, 10 stamens in two whorls of five and fused to the corolla, pollen grains in tetrads 32 ± 3 μm in diameter, and a single pistil with inferior ovary. Fruit (Figure 1A) is a true berry composed of 10 pseudolocules each with several small seeds. We found that the average number of perfect seeds was 12 ± 10 and that of imperfect seeds *sensu* Bell (1957) up to 71 per berry.

*Acronyms follow *Index Herbariorum* (Holmgren and Keuken 1974).

FIGURE 1. A and B. Parts of the mature shoot of *Vaccinium myrtilloides*: (A) fruiting shoot with characteristic pubescent stems and entire leaves; (B) a single floret.

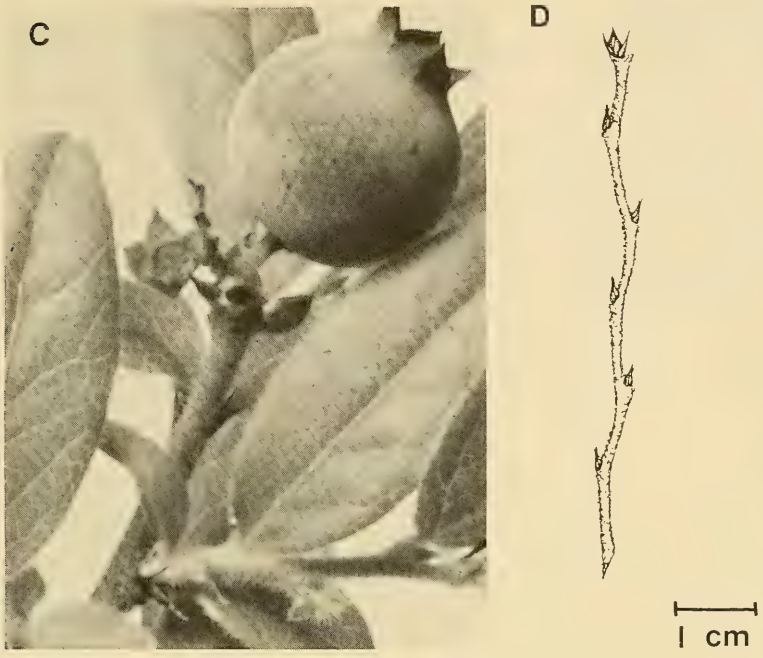

FIGURE 1. C and D. Parts of the mature shoot of *Vaccinium myrtilloides*: (C) berry and pilose twig; (D) winter twig with sharply acuminate bracts.

(e) Subspecies. None reported.

(f) Varieties and forms. Lepage (1951) described the taxon *integrifolium* which he placed in *V. angustifolium*. These plants have mostly glabrous leaf blades — only the margins and midveins are pubescent or pilose; the leaf margins are entire; the twigs of the current season are pubescent in lines; and the perennating bud scales are sharply accuminate. Phenotypically at least these (var. *integrifolium*) plants fit better in *V. myrtilloides* than *V. angustifolium*. Moreover, the plants we have grown from seed are diploid, a characteristic yet to be found in *V. angustifolium* (see Hall and Aalders 1961; Bent and Vander Kloet 1976; and Hersey and Vander Kloet 1976; among others). Furthermore, experimentally this group interbreeds freely with *V. myrtilloides* but not with *V. angustifolium*. Consequently we consider this taxon of somewhat glabrous plants hybrids of *V. myrtilloides*.

Vaccinium myrtilloides forma *chicoccum* (Deane) Fernald is the white-fruited form. White fruit in *V. myrtilloides* is inherited as a simple recessive mendelian factor (Aalders and Hall 1962).

Boivin (1966) treated *V. myrtilloides* as a variety of *V. angustifolium* but as Tables 1 and 2 of Vander Kloet (1977) amply show, this taxon is both morphologically and biologically distinct from *V. angustifolium*.

(g) Ecotypes. None reported, but likely.

(h) Chromosome numbers. Longley (1927) first reported 12 bivalent chromosomes for *V. myrtilloides*. Subsequent counts by Darrow et al. (1944), Hall and Aalders (1961), Whitton (1964), Löve and Löve (1966), and Hersey and Vander Kloet (1976) have verified $2n = 24$ for both American and Canadian specimens. The only chromosomal anomaly found so far was a diploid–tetraploid chimera from Walden, Maine (Whitton 1964).

3. *Distribution and Abundance*

(a) Geographic range. Vaccinium myrtilloides is a Nearctic endemic, extending from central Labrador to Vancouver Island (Figure 2). It extends from almost 61°N in the Northwest Territories southward to several isolated uplands in the Appalachian Mountains, 39°N. Although Fernald (1950), Ryan (1974), and Scoggan (1978) report *V. myrtilloides* from the Island of Newfoundland, no herbarium specimens are extant at A*, ACAD, BM, CAN, DAO, GA, GH, K, MICH, MIN, NCSC, NCU, NEBC, NFLD, NY, NYS, PH, QK, TEX,

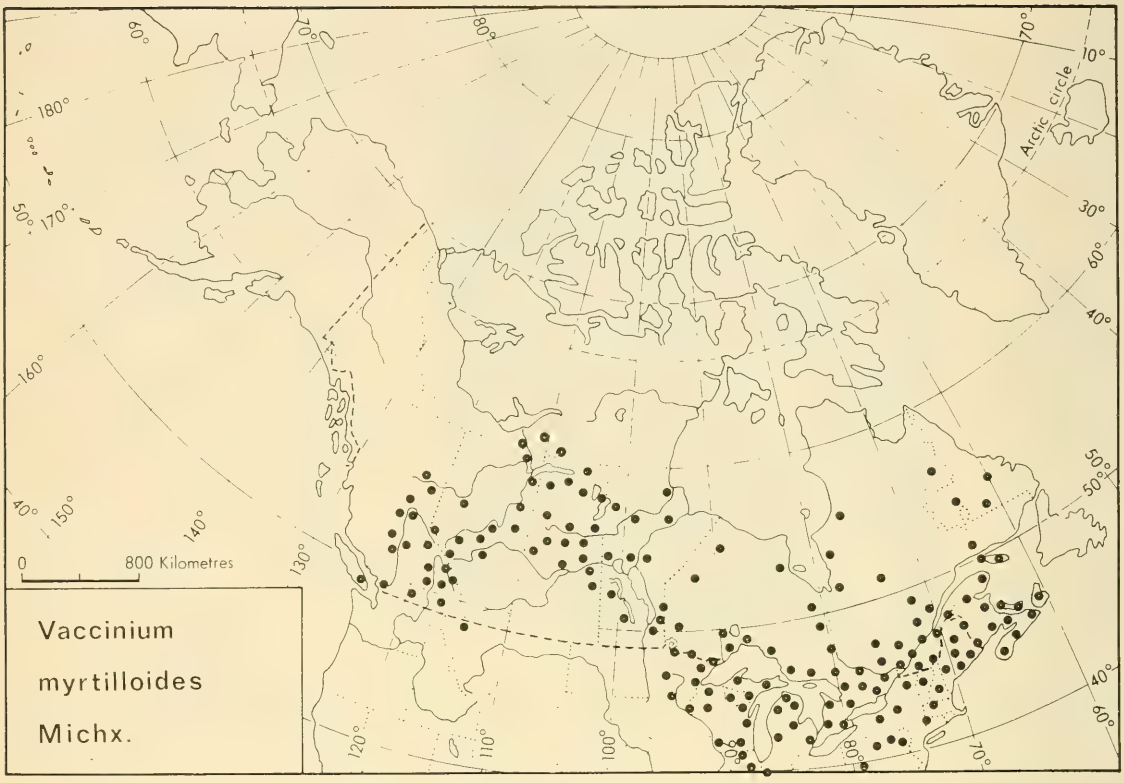

FIGURE 2. Distribution of *Vaccinium myrtilloides*.

TRT, US, and WIS, nor have the authors, after repeated searches on the Island, found the plant there. Szczawinski (1962) thought that *V. myrtilloides* was introduced to the Fraser Delta (he listed no specimens from Vancouver Island); however, Hebda (1979) and *in litt.* regards the species as native both in Fraser Delta and on Vancouver Island, but quite disjunct — nearest stations lie some 200 km ENE into the interior lodgepole pine forest of south central British Columbia.

(b) Altitudinal range. Throughout its range *V. myrtilloides* occurs from about sea level to rarely above 1200 m above sea level on mountain slopes.

4. *Physical Habitat*

(a) Climatic relations. Since *V. myrtilloides* occurs throughout several of Rowe's (1972) Forest Regions, viz., Subalpine, Boreal, Great Lakes — St. Lawrence and Acadian, we infer that the species is adapted to a wide range of climatic conditions. It tolerates a potential growing season of 200 d in the south to 100 d in the north (Atlas of Canada 1974), and occurs in subarctic areas of widespread permafrost (Brown 1967) to temperate regions. Moreover, following the Thornthwaite Classification system as applied to Canada by Sanderson (1948), *V. myrtilloides* ranges from a perhumid climatic type on the East Coast to a dry subhumid type in the west. Numerous small-scale climatic descriptions are also available, e.g., Gaudreau (1979: pp. 12–15).

Moore (1965) regards the species as winter hardy. Indeed Bell and Burchill (1955) observed that in the absence of snow cover during winter both *V. myrtilloides* and *V. angustifolium* are killed back to ground level, and that during spring cold snaps, up to 16% dead florets are found in exposed buds. Reader (1979) found that spring frost damage in blossoms began at –1°C and was complete at –10°C.

Bell and Burchill (1955) conclude that their study of winter bud hardiness supports Wulff's (1943) hypothesis that the Ericaceae did not evolve in an area of marked climatic periodicity and that many of its genera, including *Vaccinium*, are in disharmony with low winter temperatures.

Camp (1945) reported that *V. myrtilloides* is quite shade tolerant, and we have observed plants just surviving in closed canopy White Spruce (*Picea glauca*) – Balsam Fir (*Abies balsamea*) stands in central Nova Scotia and Cape Breton. In canopy openings, however, the plants both flowered and fruited. Likewise Smith (1962) found that populations of *V. myrtilloides* in Alberta occurred under low light intensity, indeed had a wider adaptability to shade than the associated conspecific *V. vitis-idaea*.

Seed germination occurs only after periods of wet weather in late summer and autumn.

(b) Physiographic relations. One of the most important factors limiting flowering and subsequent fruit development is the occurrence of late spring frosts in low-lying areas (Reader 1979). *Vaccinium myrtilloides* germinates, thrives, and reproduces well by rhizomes on both mineral and organic soils provided adequate moisture and aeration are available. These soils are quite acidic: 32 soil samples collected from *V. myrtilloides* sites in Nova Scotia, New Brunswick, Maine, Quebec, Eastern Ontario, Alberta, and British Columbia gave pH values ranging from 3.3 to 5.6; organic matter content varied from 3 (a gravel bar at Blue River, British Columbia) to 93% (hummocks near Louisbourg, Cape Breton, Nova Scotia). Similar pH values were recorded by Smith (1962) for Rocky Mountain House, Alberta, and by Gaudreau (1979), who also gives extensive information on the availability of exchangeable cations in podzolic soils of the Tanginan Hills near Chicobi Lake, Abitibi-West, Quebec.

The rhizome system of this species, once established, plays an important role in preventing slope erosion. Should soil particles be washed into the network of rhizomes and shoots, new roots and shoots develop in the additional soil, favoring the plant and retaining the soil.

Jeglum (1971) found that the presence of *V. myrtilloides* in the peatlands of Saskatchewan indicated very oligotrophic conditions (pH 3.0–3.9) as well as indicating that the water level was more than 80 cm below ground surface.

(c) Nutrient and water relations. The nutrient requirements of a slow-growing, woody perennial such as *V. myrtilloides* are much less than many herbaceous species especially those of agronomic value. The nutrient levels found in mature leaves of *V. myrtilloides* (Table 1) are similar to those reported for *V. angustifolium* (Townsend et al. 1968) and *V. macrocarpon* (Townsend and Hall 1971). The nutrient occurring in greatest amounts is N which generally occurs in the concentration range of 1.5–2.0%. Phosphorus is lowest at about 0.1%. Townsend and Hall (1970), working with *V. angustifolium*, cited the range of concentration of K as 0.40–0.55%, Ca as 0.40–0.65, and Mg as 0.15–0.20, and a perusal of Table 1 indicates a fairly close concurrence. The values for the minor elements Fe, Mn, and B are also similar to those reported in the papers cited above. Manganese values are often exceedingly high in leaves of *Vaccinium* species first reported by Lockhart and Langille (1962). Some of the observed tendencies in nutrient levels can be ascribed to the advancing growing

TABLE 1—Nutrient levels in mature leaves of *Vaccinium myrtilloides* from various locations, based on dry weight[a]

	%					μg/g		
Clone[b]	N	P	K	Ca	Mg	Fe	Mn	B
NS 221673	2.00	0.14	0.52	0.38	0.10	20	452	16
NB1[c]	1.34	0.21	0.39	0.67	0.28	104	1343	25
NB2[c]	1.15	0.19	0.48	0.67	0.31	106	735	22
NB3[c]	1.17	0.10	0.36	0.55	0.24	105	777	25
NB 829877	1.70	0.09	0.44	0.66	0.20	34	382	40
Me 623877	1.60	0.09	0.34	0.62	0.22	70	304	54
PQ 322674	1.80	0.13	0.38	0.42	0.14	24	282	30
PQ 513774	1.80	0.10	0.30	0.48	0.18	96	400	24
E. Ont 75-35	1.80	0.10	0.26	0.56	0.22	44	458	58
Wisc.[d]	1.45	0.15	0.44	0.52	0.27	192	2177	32
BC 128879	1.40	0.11	0.24	0.56	0.22	148	202	24

[a]We thank B. Dykeman for performing the leaf tissue analysis.
[b]Clones are numbered by letters indicating Canadian province or state of the United States, followed by sample number, day, month, and year, e.g., NS 221673, Nova Scotia; sample 2, collected on 21 June 1973. Vouchers in ACAD.
[c]Provenance, sandy soil at Hoyt, New Brunswick (coll. B. Dykeman, NB Dept. of Agriculture).
[d]Gerloff et al. (1964).

season. Townsend and Hall (1970) found the nitrogen concentrations decrease during the growing season while calcium and magnesium accumulate in the leaf tissue. Both NS221673 and PQ322674 (collected on the first day of summer) have the lowest levels of Ca and Mg, and highest of N; the remainder were collected in July and August.

Gorham and Gordon (1960) discovered that *V. myrtilloides* is very sensitive to sulfur dioxide pollution and therefore we think the species has promise as an indicator species to monitor acid-rain.

The taproot (Hall 1957) may penetrate to >1 m into the soil, allowing use of subsoil moisture reserves. Smith (1962), however, found no taproots on the *V. myrtilloides* colonies he excavated along slopes at about 1100 m, Rocky Mountain House, Alberta. These may have been destroyed because of slope soil creep since seedlings (Figure 3) from Alberta and British Columbia do develop taproots. Smith (1962) also found that the depth of the rhizomes varied from 4.5 ± 0.9 to 9.0 ± 2.8 cm depending on the thickness of the organic horizon. The thicker the organic horizon, the shallower the rhizome system.

In the Acadian Forest Region of New Brunswick, Flinn and Wein (1977) gave a rhizome depth of 8 ± 1 cm for *V. myrtilloides*.

5. *Plant Communities.* Within the greater part of its transcontinental range from Nova Scotia to British Columbia (Figure 2), *V. myrtilloides* is a common understory shrub in a variety of drier and less fertile coniferous forest and woodland communities, achieving highest abundance and fidelity on well-drained sandy sites dominated by *Pinus* spp. (Table 3). It also occurs, however, on xeric rock outcrops and hygric peatlands, and Maycock and Curtis (1960) have shown that it has a bimodal distribution along the moisture gradient in forests of the upper Great Lakes region, i.e., peaks of presence and abundance on dry sites and wet sites.

The species is probably most abundant, in terms of total biomass and fruit production, in young, postdisturbance communities, e.g., recently burned pine forests from western Quebec to British Columbia, and recently clear-cut forests in New Brunswick and Maine now managed as blueberry fields by commercial growers (Hall 1959).

On heath barrens in Nova Scotia (Hall and Aalders 1968), old fields in New Brunswick (Hall 1959), and granite-gneiss outcrops in eastern Ontario (Hall et al. 1979) *V. myrtilloides* is present but usually much less abundant than *V. angustifolium*. In the upper Great Lakes region and northwestern Ontario these two species

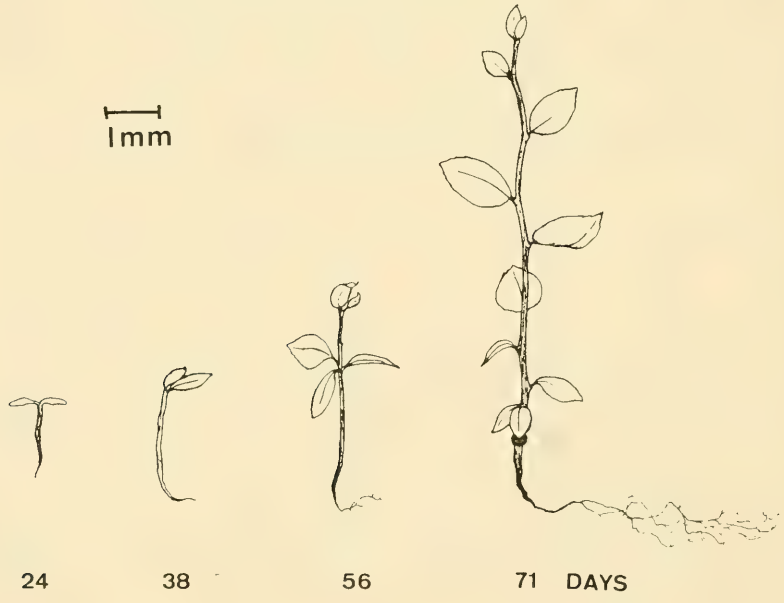

FIGURE 3. *Vaccinium myrtilloides* seedlings. Berry collected from alder forest at Blue River, British Columbia, on 29 August 1979 and seedlings grown from seed in the greenhouse at Acadia University, Wolfville, Nova Scotia.

TABLE 2—Summary of the mean ±SE values for exchangeable cations of *Vaccinium myrtilloides* soil from several granitic outcroppings in the Thousand Island Region of eastern Ontario

Site	*N*	Cation content (mmol/g dry soil)				
		Ca^{++}	Na^{++}	Mg^{++}	K^{+}	Mn^{++}
Washburn, Frontenac County	18	1.79±0.39	0.14±0.01	0.53±0.11	0.31±0.05	0.40±0.14
Mt. Fitzsimmons, Ivy Lea, Leeds County	10	1.72±0.60	0.13±0.02	0.47±0.09	0.35±0.05	0.16±0.11
Rock Dunder, Morton, Leeds County	19	2.75±0.54	0.15±0.01	0.81±0.13	0.40±0.06	0.56±0.20
Gananoque, Leeds County	4	3.92±1.04	0.13±0.02	0.62±0.14	0.29±0.02	0.66±0.27
Charleston Lake, Leeds County	2	4.25±2.35	0.11±0.02	1.05±0.50	0.30±0.11	0.23±0.11

frequently co-dominate the dwarf shrub strata of xero-mesophytic pine woodlands (Maycock and Curtis 1960) (Table 3). West of Lake Winnipeg on the boreal interior plains, however, where *V. angustifolium* does not occur (Hall et al. 1979), *V. myrtilloides* is the only blue-fruited *Vaccinium* in many *Pinus banksiana* woodlands (Table 3) except on colder sites where *V. caespitosum* sometimes occurs with it. On higher-elevation, moister sites in Alberta and British Columbia *V. membranaceum*, *V. myrtillus*, and *V. scoparium* replace *V. myrtilloides* (Wali and Krajina 1973; La Roi and Hnatiuk 1980). In northern boreal woodlands beyond the northern limits of *V. myrtilloides* the dominant blueberry is *V. uliginosum* (Viereck and Dyrness 1980).

Hall (1959) reported *V. myrtilloides* cover values >25% in cleared woodlots of New Brunswick (Table 3). Segadas-Vianna (1955) found *V. myrtilloides* in numerous bog communities of Ontario and Quebec (Table 3). La Roi (1967) tallied *V. myrtilloides* in 11 of 19 *Picea glauca – Abies balsamea* stands from Cape Breton to NW Manitoba, but its cover was never >1% in them; in contrast, the species occurred in 16 of 20 *P. mariana* – feather moss stands from central Alberta to New Brunswick with cover values up to 5% east of Lake Superior (Table 3). Curtis (1959) recorded *V. myrtilloides* in 73% of his northern wet forests in Wisconsin. Rowe (1956) classified *V. myrtilloides* as a xero-mesophytic species characteristic of fresh forest types in Manitoba and Saskatchewan. Kabzems et al. (1976) found the species to be important in their *Pinus banksiana – Vaccinium vitis-idaea – Pleurozium schreberi* forest type on well-drained sites in Saskatchewan. Moss (1953) reported that *V. myrtilloides* was abundant in *P. banksiana* and *P. contorta* woodlands as well as locally abundant on the drier hummocks of peatlands in Alberta. Wali and Krajina (1973) recognized a *P. contorta – V. myrtilloides – Arctostaphylos uva-ursi – Cladina gracilis* association for very well-drained aeolin sands and sandy outwash materials in the northern interior of British Columbia; in some of their stands *V. myrtilloides* attained cover values >40% (Table 3). Within its range *V. myrtilloides* invariably has much higher presence and abundance in needle-leaf evergreen than in broad-leaf deciduous forests.

Table 3 shows the estimated cover of terrestrial bryophytes, terrestrial lichens, and vascular plant species in a representative set of seven North American plant communities in which *V. myrtilloides* is a quantitatively important component. In the recently cleared New Brunswick woodlot managed for blueberry production, *V. myrtilloides* has the highest cover of any vascular species; *V. angustifolium, Cornus canadensis, Spiraea alba, Dennstaedtia punctilobula,* and *Kalmia angustifolia* were the main associated species. In the Black Spruce – Leatherleaf bog of Quebec, *Picea mariana, Chamaedaphne calyculata,* and *Rubus chamaemorus* were the dominant species and *V. myrtilloides* had only 1% cover. In the Black Spruce – Feather Moss forest of western Quebec, *P. mariana, Ledum groenlandicum, C. canadensis, Gaultheria hispidula, K. angustifolia,* and *V. myrtilloides* were the leading vascular species. In the White Spruce – Balsam Fir forest of northern Ontario *P. glauca, A. balsamea, Diervilla lonicera, Aralia nudicaulis, Clintonia borealis,* and *Cornus canadensis* were the cover-dominant species and *V. myrtilloides* had only 0.7% cover. In the mixed Jack, Red, and White Pine forest of upper Michigan, *Pinus banksiana, Pteridium aquilinum, Pinus strobus, Vaccinium angustifolium,* and *V. myrtilloides* were the dominant vascular species. In the Jack Pine forest of northern Alberta *V. myrtilloides* was the third-ranked vascular species after *P. banksiana* and *V. vitis-idaea,* with *C. canadensis* and *Linnaea borealis* next. In the Lodgepole Pine forest of northern British Columbia *V. myrtilloides* ranked second after *Pinus contorta* with an estimated cover of 41%; the main associated species were *Arctostaphylos uva-ursi, V. caespitosum,* and *C. canadensis.* The latter species was recorded in six of the seven stands in Table 3 and was a leading member of the understory in five stands. The heath family (Ericaceae) has high quantitative importance in plant communities containing *V. myrtilloides*; 9 of the 24 leading vascular species listed above are heaths. Both bryophytes and lichens can attain very high cover values in *V. myrtilloides* communities (Table 3).

The material in this section was prepared and written by George H. La Roi (Department of Botany, University of Alberta, Edmonton, Alberta T6G 2E9).

TABLE 3—Species-stand table showing the percent cover of terrestrial bryophytes, terrestrial lichens, and vascular plant species in a representative spectrum of North American plant communities in which *Vaccinium myrtilloides* is a quantitatively important component. Communities include (1)* a recently logged forest in New Brunswick; (2) a Black Spruce – Leatherleaf bog in Quebec; (3) a Black Spruce – Feather Moss forest in western Quebec; (4) a White Spruce – Balsam Fir forest in northern Ontario; (5) a mixed Jack, Red, and White pine forest in upper Michigan; (6) a Jack Pine forest in northern Alberta; and (7) a Lodgepole Pine forest in northern interior British Columbia. Very rare species present in a single stand are not included

Stand number	1	2	3	4	5	6	7
Terrestrial bryophytes	—	63.0	86.6	21.3	4.5	90.0	3.0
Terrestrial lichens	—	0.5	0.3	4.8	32.5	2.0	70.0
Vascular species							
Trees							
*Abies balsamea***	—	—	0.1	10.0	0.1	0.1	—
Acer rubrum	—	—	—	—	0.4	—	—
Betula papyrifera	—	—	0.5	5.0	0.1	—	—
B. populifolia	1.0	—	—	—	—	—	—
Picea glauca	—	—	—	20.0	0.1	3.0	—
P. mariana	—	37.5	58.0	0.1	—	0.5	—
Pinus banksiana	—	—	0.1	0.1	18.6	30.0	—
P. contorta	—	—	—	—	—	—	42.0
P. resinosa	—	—	—	—	3.6	—	—
P. strobus	—	—	—	3.0	4.1	—	—
Populus tremuloides	0.4	—	0.1	2.0	—	0.5	—
Sorbus americana	—	—	0.1	2.4	—	—	—
Shrubs							
Acer spicatum	—	—	—	4.9	—	—	—
Alnus crispa	—	—	0.1	3.7	—	—	—
Amelanchier alnifolia	—	—	—	—	—	—	0.5
A. stolonifera	—	—	—	0.1	0.4	—	—
Andromeda glaucophylla	—	0.5	—	—	—	—	—
Arctostaphylos uva-ursi	—	—	—	—	—	2.0	8.0
Chamaedaphne calyculata	—	37.5	—	—	—	—	—
Corylus cornuta	—	—	—	5.0	—	—	—
Diervilla lonicera	—	—	0.1	7.6	0.1	—	—
Epigaea repens	—	—	0.1	0.1	0.8	—	—
Kalmia angustifolia	4.4	1.0	3.8	—	—	—	—
K. polifolia	—	5.0	—	—	—	—	—
Ledum groenlandicum	—	5.0	10.7	—	—	0.1	—
Lonicera canadensis	—	—	—	0.1	—	—	—
L. involucrata	—	—	—	—	—	0.1	—
Oxycoccus microcarpus	—	—	1.0	—	—	—	—
Prunus pensylvanica	3.2	—	—	0.3	—	—	—
P. virginiana	—	—	—	0.3	0.2	—	—
Pyrus arbutifolia	1.8	—	—	—	—	—	—
Rhododendron canadense	3.0	—	—	—	—	—	—
Ribes glandulosum	—	—	—	0.2	—	—	—
Rosa acicularis	—	—	—	0.1	—	0.1	—
R. gymnocarpa	—	—	—	—	—	—	0.1
Rubus idaeus	—	—	0.1	0.4	—	—	—
Salix scouleriana	—	—	—	—	—	—	0.1
Shepherdia canadensis	—	—	—	—	—	0.1	—
Spiraea alba	5.8	—	—	—	—	—	—
Vaccinium angustifolium	22.8	1.0	1.1	0.3	4.0	—	—
V. caespitosum	—	—	—	—	—	—	7.0
Vaccinium myrtilloides	**26.2**	**1.0**	**2.1**	**0.7**	**3.3**	**9.9**	**41.0**
V. vitis-idaea	—	—	—	—	—	10.6	—
Viburnum edule	—	—	0.1	—	—	0.3	—

TABLE 3—(*continued*)

Stand number	1	2	3	4	5	6	7
Forbs							
Actaea rubra	—	—	—	0.1	—	—	—
Apocynum androsaemifolium	—	—	—	0.1	0.1	—	—
Aralia nudicaulis	—	—	—	7.0	—	—	—
Aster conspicuus	—	—	—	—	—	—	0.5
A. lateriflorus	0.6	—	—	—	—	—	—
A. macrophyllus	—	—	—	2.2	—	—	—
Campanula rotundifolia	—	—	—	—	—	0.1	—
Chimaphila umbellata	—	—	—	—	—	—	0.5
Clintonia borealis	—	—	0.1	5.4	—	—	—
Coptis trifolia	—	0.5	0.1	1.0	—	0.1	—
Cornus canadensis	7.8	0.5	4.8	5.1	—	5.6	3.0
Epilobium angustifolium	0.6	—	0.1	—	0.1	0.4	0.1
Fragaria virginiana	—	—	—	—	—	0.3	—
Galium boreale	—	—	—	—	—	0.2	—
G. triflorum	—	—	—	0.1	—	—	—
Gaultheria hispidula	—	0.5	4.1	0.3	—	—	—
G. procumbens	—	—	—	—	1.1	—	—
Geocaulon lividum	—	0.5	0.3	—	—	—	—
Hieracium pratense	0.8	—	—	—	—	—	—
Hypopitys monotropa	—	—	—	—	0.1	—	—
Lathyrus ochroleucus	—	—	—	—	—	0.8	—
Linnaea borealis	—	—	0.3	2.0	—	3.9	0.5
Listera cordata	—	—	0.1	—	—	—	—
Maianthemum canadense	—	—	0.4	2.2	—	2.0	—
Melampyrum lineare	—	—	—	—	0.8	—	0.5
Moneses uniflora	—	—	—	0.1	0.1	—	—
Pyrola secunda	—	—	0.1	0.3	—	0.1	—
P. virens	—	—	—	0.1	—	—	0.5
Rubus chamaemorus	—	37.5	0.1	—	—	—	—
R. pubescens	—	—	—	0.1	—	0.1	—
Rumex acetosella	1.3	—	—	—	—	—	—
Sarracenia purpurea	—	0.5	—	—	—	—	—
Smilacina trifolia	—	5.0	—	—	—	—	—
Solidago rugosa	0.6	—	—	—	—	—	—
Streptopus roseus	—	—	—	0.6	—	—	—
Trientalis borealis	—	—	—	0.6	—	0.9	—
Viola adunca	—	—	—	—	0.2	0.1	—
V. renifolia	—	—	—	0.2	—	0.1	—
Graminoids							
Agrostis tenuis	0.4	—	—	—	—	—	—
Calamagrostis canadensis	—	—	—	—	—	0.4	—
Carex aenea	—	—	—	—	—	0.1	—
C. oligosperma	—	5.0	—	—	—	—	—
C. pauciflora	—	5.0	—	—	—	—	—
C. paupercula	—	1.0	—	—	—	—	—
C. trisperma	—	5.0	0.1	—	—	—	—
Danthonia spicata	0.8	—	—	—	0.2	—	—
Elymus innovatus	—	—	—	—	—	1.4	—
Eriophorum vaginatum	—	0.5	—	—	—	—	—
Oryzopsis asperifolia	—	—	—	—	0.1	—	0.5
O. pungens	—	—	—	—	0.4	0.1	—
Schizachne purpurascens	—	—	—	0.1	—	—	—
Pteridophytes							
Dennstaedtia punctilobula	5.4	—	—	—	—	—	—
Dryopteris austriaca	—	—	—	0.1	—	—	—
Gymnocarpium dryopteris	—	—	—	0.1	—	—	—

TABLE 3—(*concluded*)

Stand number	1	2	3	4	5	6	7
Pteridophytes (*continued*)							
Lycopodium annotinum	—	—	—	0.1	—	1.0	—
L. clavatum	—	—	—	0.1	—	0.1	—
L. complanatum	—	—	—	—	0.1	—	—
L. tristachyum	—	—	—	—	—	0.1	—
Pteridium aquilinum	3.0	—	—	0.1	17.8	—	—

*(1) Data from Hall (1959); (2) data from relevé no. 6, Table 95 in Gaudreau (1979), with Braun–Blanquet scale converted to cover; (3) data from Black Spruce stand no. 18 in La Roi (1967); (4) data from White Spruce – fir stand no. 22 in La Roi (1967); (5) unpublished data from Marquette County supplied by G. H. La Roi; (6) unpublished data from House River area supplied by G. H. La Roi; (7) data from relevé no. 44, Table 3 in Wali and Krajina (1973), with Domin–Krajina scale converted to cover.

**Nomenclature follows Scoggan (1978).

6. *Growth and Development*

(a) Morphology. The seed, when sown following procedure of Vander Kloet (1978), sends out a radicle after 20 ± 7 d, cotyledons emerge after 31 ± 8 d, and the first leaves unfold after 48 ± 6 d. These first leaves (Figure 3) are much smaller and usually more ovate than mature leaves, moreover they are often coarsely serrate, making identification of seedlings difficult until the first perennating buds are formed. Seedlings germinated in a misting chamber during October, transferred to a cold frame the following June, and transplanted to the field in October, do not flower or produce rhizomes until the third summer. Once the plant has attained a diameter of about 20–30 cm and rhizome growth occurs in several directions, expansion of the clone is more rapid. Smith (1962) found that in mature plants rhizome length ranged from 100 to 1400 cm and produced an average of one to two shoots for each 100 cm of rhizome length, depending on the density of the overstory. Hall (1957) observed a maximum of five growth rings in the eldest rhizome of *V. myrtilloides* while the taproot of the same specimen had 15 growth rings and a diameter of 1 cm.

(b) Physiology. Little is known about the physiology of *V. myrtilloides*. Usually this species is lumped with *V. angustifolium* under the general rubric of lowbush blueberry culture, but the physiological work is invariably carried out on *V. angustifolium* (e.g., Hall et al. 1970). Wood and Wood (1963) reported that there was more sucrose in the nectar of *V. myrtilloides* than in *V. angustifolium*. Hilton and Barker (1962) have unpublished data which suggests equimolar quantities of glucose and fructose and only traces of sucrose in frozen berries of *V. myrtilloides*.

The physiology of flowering is also poorly known. We found that apical abortion precedes the onset of flower bud induction. However, the causality of apical abortion is poorly understood. Hilton and Barker (1962) suggested an endogenous system linked in part to auxin production and apical activity. We are currently testing responses of *V. myrtilloides* under different photoperiodic regimes.

(c) Phenology. Vaccinium myrtilloides overwinters in a leafless state, with greenish, yellowish, or brown twigs. Flower primordia are formed in the previous late summer, shortly after the cessation of vegetative growth, but may continue until late October if air temperatures remain $>0°C$ with extended periods greater than 10°C (Bell and Burchill 1955). These workers found that by early winter, the immature flowers have a completely turned ovule, the archegonia are mature, the integument is not differentiated, but the anthers are fully formed and mature pollen mother cells are present. Thus temperature is an important regulator of phenology.

At Ivy Lea, Leeds County, eastern Ontario, the vegetative and flower buds begin to swell in late April or early May, if night air temperatures have exceeded 6°C for 4–5 d. Anthesis occurs there usually between 22 May and 28 May, a week earlier in central New York, but in Maine, Gaspé, New Brunswick, and Nova Scotia a week or 10 d later (Wood 1965). In northern Quebec, Labrador, Ungava, northern Ontario, northern Manitoba, Saskatchewan, northern Alberta, and the Northwest Territories, flowering usually occurs from late May to early July while in British Columbia flowering occurs from late May in the Fraser Delta to late June inland (personal observations; Taylor and MacBryde 1977).

Leaf and vegetative shoot development precedes, is concomitant with, or follows, flowering depending on the particular clone. The formation of a black tip at the apical meristem indicates cessation of shoot growth. At Ivy Lea, leaves harden by mid-June, turn red in early October (or which is more likely will have crisped during one of the periodic droughts that strike these outcroppings during July and August), and absciss in late October.

Berries ripen 49–68 d after flowering, depending on precipitation, temperature, and the effectiveness of the pollinators. Fruit set may be delayed (Aalders and Hall 1961) if the pollinators carry a mixed load, which they frequently do (Vander Kloet 1976).

7. *Reproduction*

(a) Floral biology. In eastern Ontario, the flowers are primarily pollinated by andrenids especially *Andrena vicina* and *A. carlini* (Vander Kloet 1972). The 4- to 5-mm-long corolla is not readily manipulated by *Bombus*, nevertheless *B. ternarius* and *B. terricola* are frequent visitors along with andrenids in Maine and in the Maritimes (Boulanger et al. 1967). Likewise Reader (1977) observed *Apis mellifera*, *Bombus* spp., andrenids, and dialictids on *V. myrtilloides* in western Ontario. The latter also noted that the visitation rate to *V. myrtilloides* flowers was about 9 per minute for *Apis mellifera,* 13 for *Bombus* spp., and 4 for andrenids and dialictids. Nectar volume is 0.3 ± 0.11 µl per flower of which some 70% are dissolved solids (Reader 1977).

The 10 stamens are functional as soon as the flowers fully open and produce 2.4×10^3 tetrads (Reader 1977), but the stigmata do not become receptive until 2–3 d later. After pollination, the greenish-cream colored corolla turns pink and a few days later abscises.

Experimental pollination trials indicate that selfing is generally not successful, but both Reader (1977) and Whitton (1964) reported successful selfing in the wild. The results of controlled intercrossing and selfing of six populations of *V. myrtilloides* are given in Table 4.

The vascular anatomy of the ovary has been described by Palser (1961).

(b) Seed production and dispersal. It is rare to find a seedless berry of *V. myrtilloides* even when the number of berries per unit area of plant is low. The number of seeds per berry in crosses is given in Table 4. The American Robin (*Turdus migratorius*) is a major seed disperser in southwestern New Brunswick as it often feeds and migrates just before the berries are harvested by man (Eaton 1957). By growing seeds from scats of Black Bear (*Ursus americanus*), we have found *inter alia,* seedlings of *V. myrtilloides*. The number of large, plump, viable seeds per berry in the field is 16 ± 10 which weigh 26 ± 7 mg/100 seeds based on 250 samples. Number and weight of seeds are not correlated (Vander Kloet, unpublished data) and depend on genetic factors and environmental conditions. Should the weather be warm and dry during anthesis, pollinators tend to be more active and berries have higher seed counts.

(c) Seed viability and germination. Viability is reduced by at least 10% after excretion by birds and mammals (Krefting and Roe 1949). Nichols (1934) reported a germination success of 20%. We obtained 30% and could not find any difference among samples that had been frozen, held in the refrigerator at 1°C, and freshly harvested ones. Two of 16 batches showed a bimodal germination, i.e., several seeds germinated after 18 d and these had their second set of leaves when a second lot of seeds began to germinate 76–82 d after sowing. Seeds of *V.*

TABLE 4—Effect of self-pollination and cross-pollination on fruit set and seed number under greenhouse conditions in *Vaccinium myrtilloides* for the years 1976 to 1978

Parentage of cross	Number of flowers pollinated	Percent set	Number of seeds per berry	Percent germination
Self-pollinations				
ONT 75-41* (1 plant)	50	0	—	—
PQ 324776 (3 plants)	59	0	—	—
NS 222773 (5 plants)	50	6	1	25
NS 517773 (3 plants)	50	4	7	44
NS 13873 (2 plants)	50	0	—	—
NS 221873 (2 plants)	50	10	2	25
Cross-pollinations				
ONT 41 × NS 222773	119	32	9±2	11
PQ 324776 × NS 517773	125	51	8±2	46
NS 221873 × NS 517773	150	73	31±7	23
NS 13873 × NS 222773	100	65	16±6	51
NS 222773 × NS 517773	100	59	20±11	37

*Vouchers in ACAD. Plants are numbered by letters indicating province followed by sample number, day, month, and year, e.g. NS 222773, Nova Scotia; sample 2 collected on 22 July 1973.

myrtilloides germinate best when sown on a 1:1 sand–peat mix (pH 4.5) in a misting chamber in a greenhouse.

(d) Vegetative reproduction. Asexual reproduction occurs when the older rhizomes senesce, are cut by slope creep, partially killed by fire, by shading, burrowing, and/or frost heaving. Smith (1962) found that rhizome depth and shoot number were influenced by location.

8. *Population Structure and Dynamics.*

(a) Dispersion patterns. Lateral growth of the rhizome system below ground is a means for continuous advancement of ramets of a particular clone. Branching of rhizomes is strongly dichotomous following the cessation of growth in the dormant period. Injury to the growing point will produce a similar effect as two lateral buds are then stimulated to grow one on either side of the original growing point. Rhizome growth continues as long as a few shoots develop and translocate foodstuffs back to the storage tissues of the rhizome such as the parenchyma cells of the pith. Thus *V. myrtilloides* frequently shows a contagious, clonal dispersion.

Long-distance dispersal is by seed. The genetic diversity found in the seedlings of *V. myrtilloides* offers a multitude of new genotypes in each new habitat (Hall and Aalders 1961). Under heavy competition in old fields seedling growth is slow, requiring at least five years for a plant to reach 15 cm in diameter (Hall 1957; Eaton and Hall 1961).

Once a plant becomes established it takes a major change in vegetation such as the development of a multilayered overstory to destroy the clone. In the 25 to 30 years that are often required for the forest canopy to develop, the *V. myrtilloides* clone may grow up to 10 m in diameter and spread to adjoining areas. The most destructive factor is cultivation and even this may be beneficial since it cuts the rhizome into segments that continue to grow and produce shoots (Hall 1963).

(b) Growth and turnover rates. Once a plant becomes established it can persist almost indefinitely, though often in a weakened condition. Roland (1946) considered *V. myrtilloides* to be a relict in certain poplar woods of well-drained sandy areas of the Annapolis Valley in Nova Scotia.

(c) Successional role. Vaccinium myrtilloides is one of the lesser shrubs in the successional sequence from abandoned hayland to forest in the Maritime Provinces (Hall 1959). Following clearfelling of *A. balsamea* and *Picea rubens* in the same region, weak plants of *V. myrtilloides* and other relatively heliophytic woodland species produce vigorous shoots which quickly restore their vigor and establish a dense pioneer stage leading back to the climax fir–spruce forest (Hall 1955).

Farther west where *V. myrtilloides* is an important understory shrub in pine forests and woodlands (*see* Section 5) which are periodically burned over by wildfires (Rowe and Scotter 1973), some rhizomes usually survive even the hottest fires if the soil is deep enough to afford refuge (Flinn and Wein 1977). On relatively infertile and dry sandy sites where competition from herbs is not intense, *V. myrtilloides* populations expand rapidly, with peak flower and fruit production usually occurring 10–20 years after fire and prior to tree canopy closure, after which they decline in cover and fruit production.

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9. *Interaction with Other Species*

(a) Competition. In the Acadian Forest Region *V. myrtilloides* is an important component of some forests (Loucks 1962); in these it frequently occurs with *D. punctilobula* (Hay-scented Fern), *Lycopodium* spp. (a club moss), *C. canadensis* (Bunch Berry), *Maianthemum canadense* (Wild Lily-of-the-Valley), and the conifers of the upper story (Hall 1955). *Vaccinium myrtilloides* has a much higher survival potential than its congener *V. angustifolium* in the mature Acadian spruce–fir forest (Hall 1959).

In lowbush blueberry fields of the Acadian Forest Region that have recently been developed from woodlots, *D. punctilobula, Pteridium aquilinum* (Bracken), *S. alba* (Meadowsweet), *Prunus pensylvanica* (Pin Cherry), *C. canadensis, Rhododendron canadense* (Rhodora), and *K. angustifolia* (Lambkill) are the chief competitors (Hall 1959) (Table 3).

(b) Symbiosis. The pollinators of *V. myrtilloides*, mainly bumblebees or related genera, have been described in Section 7(a).

At present there is considerable interest in mycorrhizal associations in *Vaccinium* species (Pearson and Read 1973a, b). In Canada, the Department of Forestry at Laval University has a contract with Agriculture Canada to demonstrate the presence and importance of mycorrhizae in lowbush blueberries. Englander (1979), working with *Rhododendron* (Ericaceae), found that radioactive phosphorus (P^{32}) applied to the fungal fruit body

appeared within a short time in the suspected host plant; when the isotype was applied to twigs of the host plant it soon appeared in the fungus.

(c) Predation and parasitism. The insects found on *V. myrtilloides* are generally the same as those found on *V. angustifolium*. G. W. Wood (personal communication) states, "the pubescence of the foliage of *V. myrtilloides* appears to hinder the feeding and movement of the thrips larvae and thus acts as a factor of resistance. Injury to *V. myrtilloides* by thrips is not typical. The leaves do not curl as tightly as in the case of *V. angustifolium*, and the occurrence of aphids and other insects in the leaf galls is much more common." Feeding by larvae of *Actebia fennica* (Black Army Cutworm) starts in the early spring as soon as the flower buds of *V. myrtilloides* begin to swell; they make a small hole in the side of the flower buds and eat out the inner tissue; feeding is mainly nocturnal (Wood and Neilson 1956). From mid-June to late July immediately following bloom in bearing fields and in recently burn-pruned areas *Neochlamisus cribripennis* (Blueberry Case Beetle) larvae may feed on foliage, stems, and fruit. The adults emerge in late August and possibly feed on the bark until winter sets in (Wood 1970). Eggs of *Frankiniella vaccinii* and *Taencothrips vaccinophilus* (Blueberry Thrips) are laid in the shoots in late May or early June and the larvae feed and live in the shoots from June to August; their presence is recognized by the characteristic wrapping of the reddish leaves about the stems (Wood 1956 and 1960). Larvae of *Altica sylvia* (Blueberry Flea Beetle) attack blueberry fields from early to mid-June (Maxwell et al. 1953).

Orgyia leucostigma (Whitemarked Tussock Moth) larvae attack a variety of broadleaf trees and evergreens and may feed heavily on *V. myrtilloides* (Wood 1979). As the fruit ripens the adults of *Rhagoletes mendax* (Blueberry Maggot) begin to lay their eggs in fruit (Wood 1962); this species has not been found in Labrador and Quebec.

Fruits of *V. myrtilloides* are eaten by several birds, most notably, American Robin. Foliage and twigs of *V. myrtilloides* are eaten by a number of mammals chief of which are *Odocoileus virginianus* (White-tailed Deer) and *Sylvilagus floridanus* (Eastern Cottontail). Sheep selectively avoid *V. angustifolium* and *V. myrtilloides* and consume the grasses and sedges between or associated with these species (Hall 1954). Fruits are eaten by *Procyon lotor hirtus* (Raccoon), *Odocoileus virginianus, Vulpes vulpes* (Red Fox), *Ursus americanus* (Black Bear), and *Erethizon dorsatum* (Porcupine).

Important fungal diseases of *V. myrtilloides* are *Botrytis cinerea* (Grey Mold), *Exobasidium vaccinii* Wor. (Red-leaf), and *Pucciniastrum gêoppertianum* (Witches-broom) (Conners 1967). We think Monilinia Blight caused by *Monilinia vaccinii-corymbosi* occurs on *V. myrtilloides*, but it has not been reported as such because of field reports on "lowbush blueberry" or "blueberries." Parmelee (1977) records the presence of *Microsphaera vaccini* on *V. myrtilloides*.

(d) Toxicity and allelopathy. Devlin (1980) reports a growth inhibitor in *V. macrocarpon* (Cranberry) leaves but none is known for *V. myrtilloides*.

10. *Evolution and Migration.* Camp (1942) classified *V. myrtilloides* as a member of the basic diploid group $2n = 24$) which arose from phyletic divergence as opposed to his "mere speciation" which could occur whenever several of the diploid taxa introgress. Subsequent allopolyploidy or autopolyploidy would produce polyploid taxa — taxa, which, Camp argued, are the end of the evolutionary process and not the beginning.

We postulate that section *Cyanococcus* originated in South America, migrated through the Caribbean Islands (there are no members of the section along the isthmus between North and South America, including Mexico, and southwestern USA) onto the sand dunes, relict sand dunes, and pine flatwoods of peninsular Florida, an area where the diploid *V. darrowii* still thrives. The trend has been to lose the evergreen and xeromorphic characters such as small, thick, glaucous, inrolled leaves [glaucescence has been shown to retard transpiration (Andersen et al. 1979; Freeman et al. 1979)] of the present *V. darrowii* to a more temperate deciduous plant with fewer xeromorphic characters as in *V. tenellum* (Table 5), or with larger leaf blades as in *V. pallidum*. A concomitant reduction in seed weight (Crouch and Vander Kloet 1980) and pollen size has also been observed as the group drifted northward with the North American continent and was subjected to an era of continuous climatic cooling which transformed the Arcto-Tertiary deciduous forest and *V. pallidum* into more boreal types where the shorter growing season selected against larger leaf blades and heavier seeds.

The subsequent glacial epochs of the Pleistocene forced many of the northern diploid populations to migrate southwards, which resulted in the formation of several hybrid populations and species such as *V. myrsinites, V. hirsutum, V. corymbosum,* and *V. angustifolium* (Camp 1942, 1945; Vander Kloet 1977, 1980).

Hybrids between *V. myrtilloides* and *V. boreale* have been found in a commercial lowland blueberry field at Frizzleton, Inverness County, Nova Scotia. Hall and Aalders (1962) reported that a comparison of the

TABLE 5—Means and standard deviations for selected attributes of the diploid, lowbush species in *Vaccinium & Cyanococcus*

Taxon characters	*V. darrowii*	*V. tenellum*	*V. pallidum*	*V. myrtilloides*	*V. boreale*
Plant height (cm)	55±39	30±11	37±14	35±14	4±2
Habit	Evergreen	Deciduous	Deciduous	Deciduous	Deciduous
Leaf blade	Glaucous Glabrous	Glandular Pubescent	Pale Glabrous	Green Pubescent	Green Glabrous
Leaf width (mm)	4±1	10±2	17±4	12±4	4±1.5
Leaf margin	Entire	±Entire	Entire or serrate	Entire	Serrate
Corolla length (mm)	5±2	7±2	7±3	4±1	4±1
Pollen tetrads (μm)	44±2	36±2	37±2	32±3	33±3
Seed weight (mg/100 seeds)	47±8	39±6	34±6	26±7	22±2
Habitat	Pine flatwoods	Pine flatwoods	Open oak woods	Taiga	Headlands Alpine/arctic tundra
Geographical range					
Latitude	27°N–32°N	30°N–37°N	33°N–44°N	39°N–61°N	44°N–58°N
Longitude	80°W–91°W	76°W–88°W	70°W–94°W	60°W–125°W	53°W–74°W

suspected natural hybrids with artificially produced ones showed both to be intermediate between the parents in general plant form and leaf shape.

11. *Response Behavior*

(a) *Fire.* In natural communities or managed forests, *V. myrtilloides* survives wild fires or controlled burning below ground (Flinn and Wein 1977). Recolonization occurs by rhizome sprouting and the density of new shoots varies significantly depending upon whether the burn occurs in May or September. According to these same authors density of new emerging shoots is much higher after a September burn and can be explained as a result from accumulation of food reserves in the rhizomes during the growing season. Commercial stands which are burn-pruned every second year showed a marked decrease in *V. myrtilloides* abundance (Chandler and Hyland 1941). Currently we are investigating the optimum burn cycle for this species.

(b) Grazing and harvesting. Grazing by deer removes the flower buds or terminal vegetative buds which in turn stimulates dormant tissue further down the stem to grow. With flowers removed more metabolites and nutrients are directed to vegetative growth. The destruction of the terminal growing point of either the shoot or rhizome will destroy apical dominance and give rise to one or more new growing sites. The rakes used in fruit harvesting occasionally pull up pieces of rhizomes and there is considerable damage to flower buds. This poses no problem in commercial stands which are generally burn-pruned following the taking of a single crop.

(c) Flooding. Flooding during the growing season has never been reported as a problem. Even on bogs or around the margins of lakes *V. myrtilloides* is normally found growing on the tops of hummocks above the water table (Moss 1953). Thus it may not tolerate inundation.

(d) Drought. In the Maritime Provinces there is generally sufficient rainfall to meet requirements. In dry years a substantial rain of about 2 cm three to four weeks before harvest will have a favorable effect on berry size and harvest yields. Over the rest of its transcontinental range the species frequently grows on thin and/or coarse-textured soil, and drought symptoms such as leaf-browning and fruit abortion are more common.

(e) Herbicides. Vaccinium myrtilloides is resistant to Asulam and Terbacil at recommended rates for controlling, respectively, *P. aquilinum*, and grasses and sedges. Dicamba and 2,4-D applied after leaf abscission of *V. myrtilloides* for control of *K. angustifolia* may reduce the number of shoots of *V. myrtilloides* the year following application. Generally the rhizomes are not affected and growth is normal the second year.

12. *Relationship to Man*

Fernald (1950) called this species "Sour-top", an uncomplimentary name; we prefer his alternate colloquial name, "Velvet-leaf." Differences in the size, shape, color, and taste of berries exist among clones, but those of *V. myrtilloides*, when ripe, are equally as sweet and pleasant as those of *V. angustifolium*. The crop of blueberries in New Brunswick is about 2 million kg annually and of this perhaps 30% is from *V. myrtilloides* (Hall et al. 1979). Most of the berries are sold to processors in Maine who sell them as pie filling or as a component of

muffin mixes. Both *V. angustifolium* and *V. myrtilloides* are much sought after in the pine forests of the Great Lakes region, but not commercially as yet, except at Sudbury. The Cree nation makes use of western populations.

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Received 2 July 1980
Accepted 22 February 1981

Notes

Attempted Avian Predation by a Canadian Toad, *Bufo americanus hemiophrys*

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Vertebrates are rarely taken by toads (*Bufo*), which are generally characterized as avoiding relatively large prey. An exception was a 62-mm (snout-vent) Canadian Toad, *Bufo americanus hemiophrys*, found near Beausejour, Manitoba, attempting to swallow a young Red-winged Blackbird, *Agelaius phoeniceus*, which had apparently recently fallen from a nearby nest.

Key Words: *Bufo americanus hemiophrys*, Canadian Toad; predation, Red-winged Blackbird, *Agelaius phoeniceus*.

The feeding pattern of toads (*Bufo*) has been characterized by Clarke (1974) as largely that of a predator on small, often armored or noxious, insects, particularly beetles, ants, and (in the tropics) termites. Clarke acknowledged, however, that some earlier authors regarded toads in indiscriminate feeders. He also stressed that toads generally eat many small items rather than a few large ones, largely independent of the size of the toad (juvenile or adult). However, Heatwole and Heatwole (1968), and Bragg (1957) observed some increase in prey size with increase in toad size.

Vertebrates have rarely been reported as food items for toads. Campbell and Davis (1968) reported a nongravid female Gulf Coast Toad, *Bufo valliceps*, which contained a Fence Lizard, *Sceloporus undulatus*, and another which contained a juvenile Fowler's Toad, *B. woodhousei fowleri*. In their review of the literature they found only one previous report, Smith and Bragg (1949), who observed a captive juvenile *B. woodhousei fowleri* eat a small lizard in a terrarium. Overlooked by the authors were reports that a Giant Toad, *B. marinus*, had eaten a small frog (Weber 1938), "small batrachians" (= frogs) (Barbour 1930: 76) and ducklings and rats (Myers 1931: 25). Also, Alexander (1964) recorded that Giant Toads ate a variety of items from dog food to overripe avocados: an exception to the common *Bufo* response of preying only on moving objects. Subsequently, Hahn (1976) and Hughes (1978) cited additional reports of vertebrates taken by the Asian and African toads *Bufo melanostictus, B. regularis,* and *B. funereus*.

Because records of toads preying on vertebrates, especially relatively large ones, are infrequent, our observation indicates that toads cannot be completely stereotyped regarding prey size.

On 24 June 1968 between 16:15 and 19:00 during a field study of toads in southeastern Manitoba, a lethargic Canadian Toad, *B. americanus hemiophrys* (for nomenclature see Cook 1978) was found at the edge of a water-filled roadside ditch 1.6 km north of Beausejour, Manitoba. On turning the animal over, we found most of a young bird, later identified as a Red-winged Blackbird, *Agelaius phoeniceus*, protruding from the toad's mouth. Only the bird's head and part of its neck had been swallowed. Although apparently near death when found, the toad revived after the bird was removed. The toad measured 62 mm snout to vent and was a female with relatively small ovarian eggs, both pigmented and unpigmented. Comparative sizes of toad and bird are shown in Figure 1. Both were preserved at capture (NMC 11218). Among cattail (*Typhus* sp.) stems, 15 m along the ditch, was the nest of a Red-winged Blackbird, containing three young, about the size of the one the toad had seized. Godfrey (1966) gives the usual number of eggs for this species as four (range three to five). As the nest was about 0.3 m above the water, it is most likely that one nestling had fallen out of the nest into the water where its struggles attracted the toad. Bragg (1957) suggested that the nature of a potential prey's movements was important in whether it was attacked or not. Possibly its struggles were like those of a lepidopteran, fluttering at the surface of the water.

The only existing study of *B. a. hemiophrys* feeding (Moore and Strickland 1954) fits this taxon into the general pattern summarized by Clarke (1974). Lepi-

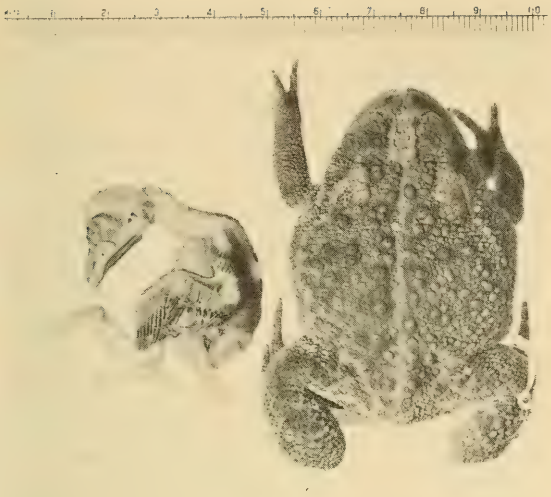

FIGURE 1. Comparison of the size of the female Canadian Toad, *Bufo americanus hemiophrys*, 62 mm snout-vent, with its prey, a nestling Red-winged Blackbird, *Agelaius phoeniceus*.

doptera feeding is apparently rare as only two are noted from the 16 adult toads examined by Moore and Strickland (1954). However, much of the range of this toad is in moderately arid environment of aspen parkland and the northern periphery of the short-grass prairie. It shows morphological trends to arid adaptations (Cook 1978). At least occasional opportunistic feeding on relatively large prey (such as Lepidoptera) could be an advantage in such habitats where the potential active period is limited by periodic aridity and generally cool evenings during a relatively short annual activity period (May through September). This might be particularly true of females that are maturing eggs for the subsequent breeding season. Later examination of the toad's stomach revealed that it was moderately full, containing beetle remains (wings etc.) and soft-bodied insects. Heatwole and Heatwole (1968) indicated that size of prey attacked tended to decrease with amount of food previously taken, but this does not seem to have held true in this individual.

We are indebted to W. E. Godfrey and H. Ouellet of the National Museum of Natural Sciences Ornithology Section, who confirmed the identification of the avian remains; and to James A. Johnston, Herpetology Section, who photographed the preserved specimens.

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Received 13 March 1980.
Accepted 20 January 1981.

Daily Movements of Red Squirrels, *Tamiasciurus hudsonicus*

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My study of the daily movements of Red Squirrels (*Tamiasciurus hudsonicus*) near Atlin, British Columbia, in 1978 showed that the shortest movements were in the prebreeding season (averaging 34.3 m, ♀♀; 88.1 m, ♂♂). Males made the greatest movements (mean to 169.9 m) during breeding and gestation whereas females made long movements (mean to 190.1 m) during lactation and postweaning. Both the breeding cycle and the availability of food supplies influence the daily movements.

Key Words: Red Squirrel, *Tamiasciurus hudsonicus*; daily movements, British Columbia.

The movements of Red squirrels (*Tamiasciurus hudsonicus*) are relatively easy to study because the animals are fairly numerous, territorial, diurnal, and vocal, and thus are easy to locate. Study of this species may help us to understand the daily movements of other, less common, and wider-ranging territorial species. Although several studies on Red Squirrel ecology have included information on movements, there has been no detailed quantitative study on the daily movements of Red Squirrels. By "territory" I refer to a more or less clearly defined area where an animal tends to segregate itself from other individuals of its species (Fitzwater 1941).

Methods

I studied Red Squirrel movements during the spring and summer 1978 near Atlin, British Columbia (59°38′N, 133°19′W). The vegetation on the 1.03-km^2 study area consisted of patches of White Spruce (*Picea glauca*) and Lodgepole Pine (*Pinus contorta*) separated by muskegs and dense stands of willows (*Salix* spp.) (Fancy 1979).

Livetrapped squirrels were marked with fur dye and metal ear tags. The location of marked squirrels on the gridded study area was recorded during daily patrols on foot. Although it was not possible to cover each part of the study area equally, all territories were visited at least once each field day. Observations of squirrel behavior indicated that my presence had no effect on squirrel movements. These methods resulted in 4150 observations, including 502 trap captures, of 94 marked squirrels.

The study period was divided into five seasons based on the female reproductive cycle. The greatest distance between any two locations at which a particular squirrel was seen on any given day was used to compare movements of Red Squirrels by sex and season. For each squirrel during each season, a mean distance was calculated from the daily distances. These mean distances for each squirrel were used in subsequent analyses.

Results and Discussion

A mean distance was not available for every squirrel each season, as some squirrels died or left the study area, while others were first observed after the study began. An analysis of variance was precluded by these missing data, by a significant interaction between sex and season, and by unequal variances, even after a square root transformation was used. A Kruskal–Wallis test (Hull and Nie 1979) was used, therefore, to test seasonal differences in the mean distance between sexes, while pairwise *t*-tests assuming unequal variances (Sokal and Rohlf 1969: 374) tested the differences in movements between sexes for each of the five seasons (Table 1).

For both males and females, the five seasonal means were significantly different (Table 1). Males made the greatest movements during the gestation and breeding seasons, while females made longer movements during the lactation and postweaning seasons. The differences between the daily movements of males and females was significant in all seasons except during the postweaning season. Males moved further than females during the prebreeding, breeding, and gestation seasons, while females moved further than males during the lactation and postweaning seasons.

Daily movements of Red Squirrels except during the breeding season are mainly associated with food gathering and territorial defence (C. C. Smith 1968). C. C. Smith (1968) found that in the daylight hours, adult squirrels spend about 80% of the time in food-related activities, and less than 1% in territorial defense. Because squirrels in habitat with a poor food supply would need to travel greater distances to meet their energy demands than would squirrels in food-rich habitats, we would expect to find a high positive correlation between the food supply of an area and the mean daily distance of territory owners on that area. Studies by Kemp and Keith (1970) and Rusch and Reeder (1978) support this because the greatest movements they detected were in poor-quality Trembling Aspen (*Populus tremuloides*) areas, while shor-

TABLE 1—Comparison of mean daily distance (m) moved by squirrels using Kruskal–Wallis tests for seasonal differences in distance moved by each sex, and *t*-tests assuming unequal variances for differences between sexes

	Males		Females		*t*-test
Season	*n*	Mean±SD	*n*	Mean±SD	*P*
Pre-breeding[1]	15	88.1+53.4	8	34.3+33.9	< 0.05
Breeding[2]	19	156.9+114.3	11	62.4+27.6	< 0.05
Gestation[3]	16	169.9+125.1	12	79.3+43.7	< 0.05
Lactation[4]	21	99.6–44.6	16	190.1+151.3	< 0.02
Postweaning[5]	19	106.8+161.6	12	151.4+93.7	ns
Bartlett's test		$P < 0.001$		$P < 0.001$	
Kruskal–Wallis statistic	$P = 0.029$		$P < 0.001$		

[1]22 March – 11 April.
[2]12 April – 9 May.
[3]10 May – 31 May.
[4]1 June – 1 August.
[5]2 August – 28 August.

ter movements were detected in White Spruce forests. M. C. Smith (1968) reported that home ranges of squirrels following a cone crop failure were considerably larger than in preceeding years, as squirrels traveled greater distances in search of food. I found a spring density of 0.5 adult squirrels per hectare; this is considerably lower than that found in other studies (Brink 1964; Wood 1967; C. C. Smith 1968; Davis 1969; Rusch 1970). Because 27.7% of my study area was covered by muskegs and dense willows, the available food supply in my study area was probably lower than that in the other areas studied.

During the breeding season, food is no longer the critical resource for male squirrels. Estrous females, receptive on only one day (C. C. Smith 1968; Rusch and Reeder 1978), represent a temporally and spatially limited resource. Because receptive females remain close to their middens during this season (Fancy 1979), males must move over large distances to increase the probability of encountering an estrous female.

The longer movements made by females during the lactation and postweaning seasons were made primarily by parturient females, presumably as a result of the increased energy demands from the birth and caring of their young. During the lactation season, lactating females each averaged 7.3 daily movements exceeding 100 m, while each male and barren female averaged 4.2 movements greater than 100 m during this season.

The results of this and other studies (C. C. Smith 1968; M. C. Smith 1968; Kemp and Keith 1970; Rusch and Reeder 1978) indicate that daily movements of Red Squirrels are influenced by the breeding cycle and the availability of food supplies within an area. Further work with this and other territorial species may enable us to predict the extensiveness of daily movements based on the available food supply of an area.

Acknowledgments

This paper is based on a portion of my M.Sc. thesis. I am indebted to Archie Mossman for his guidance during the fieldwork and for his comments on the paper.

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Received 30 October 1980
Accepted 27 January 1981

Fate of Overwintered Clutches of the Common Snapping Turtle (*Chelydra serpentina*) in Algonquin Park, Ontario

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Obbard, Martyn E., and Ronald J. Brooks. 1981 Fate of overwintered clutches of the Common Snapping Turtle (*Chelydra serpentina*) in Algonquin Park, Ontario. Canadian Field-Naturalist 95(3): 350–352.

The frequency of successful overwintering of Common Snapping Turtle (*Chelydra serpentina*) clutches in Algonquin Park, Ontario, is very low. In a 4-yr study, 42 of 257 clutches emerged in the fall of the year of oviposition. Of the 215 clutches that did not emerge in fall, only 1 overwintered successfully. This low success of overwintering clutches may be an important factor limiting the northern distribution of the Common Snapping Turtle.

Key Words: Common Snapping Turtle, *Chelydra serpentina*; nesting, delayed emergence, Algonquin Park, limiting factors.

Delayed emergence or overwintering of young in the nest occurs regularly in many species of turtles (Gibbons and Nelson 1977). There are few reports (Toner 1940; Bleakney 1963; Ernst 1966), however, of clutches of the Common Snapping Turtle (*Chelydra serpentina*) surviving over winter and no indication of how often this phenomenon might occur in a population. Therefore, in this study, we examined the frequency of successful overwintering in clutches of the Common Snapping Turtle in Algonquin Park, Ontario.

Study Area and Methods

From 1976 to 1979, we monitored nesting areas used by female snapping turtles along the North Madawaska River in Algonquin Park (45°35′N, 78°30′W) (see Obbard and Brooks 1979, 1980 for a description of the study area). A number of potential nesting areas was checked daily, morning and evening, throughout the nesting period each year, and the location of clutches was recorded. Each year the fate of 60–70 clutches was followed, and these clutches were checked frequently until late fall. Whenever possible, clutches that did not emerge in the year of oviposition were excavated and examined in May of the following year. The viability of hatchlings and of young in pipped eggs was recorded. If a clutch contained only unpipped eggs when excavated, several eggs were opened and viability of embryos was noted. Each year, a sample of unpipped eggs was retained in the laboratory to determine whether any young would hatch.

Results and Discussion

The fate of 257 clutches studied is summarized in Table 1. Only 42 clutches emerged in September or October in the year of oviposition. Of the remaining 215 clutches, 129 were excavated in spring and the rest were either destroyed by predators or were not located. Only 1 of the 129 overwintered clutches that were examined contained live hatchlings. In all other cases, hatchlings and young in pipped eggs were dead. All unpipped eggs that were opened contained dead embryos, and no young hatched from eggs retained in the laboratory. However, the possibility remains that some unpipped eggs contained living embryos since not all eggs were opened and examined. There was considerable yearly variation in the frequency of successfully emerging clutches and in the stage of development reached by embryos in unhatched eggs. Factors affecting development and emergence will be considered elsewhere.

The single clutch that had live hatchlings when excavated in spring was laid 18 June 1978 on the banks of the North Madawaska River 2.3 m from the concrete abutment of a highway bridge. No hatchlings had emerged from the nest by 2 November 1978 when it was last checked. On 5 May 1979, there was still no

TABLE 1—Fate of 257 clutches of the Common Snapping Turtle in Algonquin Park, Ontario

Year	Total located during the nesting period	Evidence of emergence in fall	Destroyed by predators	Overwintered clutches			
				Total analyzed in spring	Only unpipped eggs	Hatchlings and pipped eggs	Live hatchlings
1976	64	4	9	22	20	2	0
1977	69	6	3	39	26	13	0
1978	60	20	10	41	6	35	1
1979	64	12	26	27	15	12	0
	257	42	48	129	67	62	1

evidence that any young had emerged, so the clutch was uncovered. The nest contained 16 live hatchlings, 11 dead hatchlings, and 3 infertile eggs. All young had hatched and were free of the egg shell, and all had lost the caruncle, but had unhealed yolk sac scars. There appeared to be no correlation between depth in the soil where the hatchlings were found and rate of survival. However, the sandy soil had been frost-free for some time so live hatchlings may have moved vertically in the nest chamber.

Frequency of successful overwintering of Common Snapping Turtle clutches in this study was only 1 in 129 and would be even lower if one considered all clutches laid. It is likely that this rare occurrence was fortuitous. In the case reported here, the clutch was probably protected from lethal low temperatures by deep snow cover accumulated from snow-clearing operations on the bridge. However, the actual cause of overwinter mortality is not known, and other factors such as lack of oxygen, starvation, or accumulation of waste products in unpipped eggs may be responsible.

It has been suggested that overwintering in the nest by hatchling turtles is an adaptation allowing survival in northern portions of a species' range (Carr 1952). For example, hatchling Painted Turtles (*Chrysemys picta*) commonly overwinter in the nest near Ann Arbor, Michigan (Sexton 1957). Overwintering, in the nest is common in many species of turtles in the southern and central United States (Gibbons and Nelson 1977), whereas overwintering in the northern regions has been reported as unsuccessful in the Stinkpot (*Sternotherus odoratus*) in Michigan (Risley 1933), the Spiny Softshell (*Trionyx spiniferus*) in Minnesota (Breckenridge 1960), and the Common Snapping Turtle in South Dakota (Hammer 1970). These and our data make it unlikely that delayed emergence is an adaptation to northern climates in all turtles. As Gibbons and Nelson (1977) emphasized, the costs of immediate emergence should be weighed against the costs of delayed emergence in each species. If costs of the latter are high, as found in our study, then selection should favor early dates of oviposition and fall emergence in the year of oviposition.

Common Snapping Turtle hatchlings usually emerge in the fall in Michigan (Sexton 1957), South Dakota (Hammer 1970), and Ontario (this study), and successful overwintering is probably very rare in areas where frost extends below the depth of the nest. The inability of hatchlings to overwinter successfully in the nest is probably a major factor limiting the northern distribution of the Common Snapping Turtle, and possibly other turtle species.

Acknowledgments

This study was supported by grants from the Canadian National Sportsmen's Fund (grant 3-R 39) and the Ontario Ministry of Natural Resources. We thank the Ontario Ministry of Natural Resources for permission to work in Algonquin Park and for use of the facilities of the Wildlife Research Station. We thank G. Nancekivell, D. Schluter, R. Stewart, D. Oliver, A Green, R. Moses, T. Friesen, I Ross, and D. Campbell for assistance in the field.

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Received 16 September 1980
Accepted 27 January 1981

Predation and Caching of Seabirds by Red Foxes (*Vulpes vulpes*) on Baccalieu Island, Newfoundland

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Red Foxes (*Vulpes vulpes*) prey on and cache many burrow- and cliff-nesting seabirds on Baccalieu Island, Newfoundland, possibly for use in winter when food is scarce or unavailable. The large seabird population do not appear to be threatened by the small number of foxes on the island, although the situation is potentially dangerous for burrow-nesting species (Leach's Storm-Petrels (*Oceanodroma leucorhoa*), Atlantic Puffins (*Fratercula arctica*)).

Key Words: seabirds, predation, foxes, caches, Newfoundland, Leach's Storn-Petrel, Atlantic Puffin, Red Foxes.

Nesting on cliffs and in burrows are considered to be antipredator adaptations (e.g. Tuck 1961). Both aerial and terrestrial predators, however, are often successful against these birds (Nettleship 1972; Montevecchi 1978; Jones and Byrd 1979). In this paper cases of predatory and caching activities by Red Foxes (*Vulpes vulpes*) on cliff— and burrow-nesting seabirds on Baccalieu Island, Newfoundland (48°07′N, 54°12′W), are described.

Foxes were first seen on the island in winter 1959–1960, when pack ice jammed the 3.2 km channel separating the island from the mainland (E. Blundon and P. Rice, Baccalieu Island, personal communication). Currently they are the only mammals that inhabit the island. Baccalieu Island (6 × 1 km) supports hundreds of thousands of breeding pairs of Leach's Storm-Petrels (*Oceanodroma leucorhoa*, possibly the largest colony in the world), and many thousands of Black-legged Kittiwakes (*Rissa tridactyla*), Atlantic Puffins (*Fratercula arctica*), and Common Murres (*Uria aalge*) (Brown et al. 1975).

In 1976–1978, we found expanses (hundreds of square metres) of petrel nesting ground on grassy slopes dug out by foxes (Figure 1). In 1978, we found fragments in fox scats or chewed remains of 11 eggshells of murres, kittiwakes, puffins, and Northern Gannets (*Morus bassanus*). Some eggshells may have been discarded by Common Ravens (*Corvus corax*) and subsequently chewed up and ingested by foxes.

On 11 June 1978, in part of an active fox den and in an adjacent burrow-like excavation (about 1.5 × 1 × 1 m), we found a cache containing fresh carcasses of 30 petrels, 3 kittiwakes, 3 puffins, a Common Murre, and a Fox Sparrow (*Passerella iliaca*), all adults. In August 1980, two other fox caches were located about 1.5 km away in an area where another den was suspected (a kit sighted with an adult fox on 21 June). One cache contained the fresh carcasses of at least 27 petrels (two chicks), 29 puffins (four chicks); the other contained 15 petrels, 9 puffins, a fledgling kittiwake, and a murre chick (K. Brink and D. Roby, University of Pennsylvania, personal communication).

We do not know the extent to which foxes cache prey elsewhere. Arctic Foxes (*Alopex lagopus*) are known to horde substantial food in a single location, though Red Foxes are not (D. Macdonald, Oxford University, personal communication). Many uneaten, discarded, petrel carcasses were found on the island, especially in the wooded areas (cf. Kruuk 1972).

We first witnessed predation on 23 June 1979 at 11:25, when a Red Fox, walking along a cliff top, caused a large number of nesting kittiwakes and murres to scatter in panic from the ledges below. The fox climbed down the nearly vertical cliff and carried a murre egg up the cliff and out of view. Sixteen murre eggs were taken in this way in 95 min. On 28 June 1979, we again saw a fox climb down this cliff, scaring off the kittiwakes and murres. This time the fox dug a

FIGURE 1. An area where burrows of Leach's Storm-Petrels were dug out by Red Foxes (photo: W. A. Montevecchi)

puffin out of a burrow in a grassy area among the ledges and carried it off.

The Red Fox population on Baccalieu apparently includes two or more adult breeding pairs, as kits have been seen in most years, and two active dens were found in 1978. In winter, Willow Ptarmigan (*Lagopus lagopus*), a few small land birds, and berries may provide foxes with limited food. The vertical cliffs around the island's perimeter and absence of beaches preclude scavenging on marine invertebrates and carrion. Winter food shortages apparently keep the population in check, and foxes may have to cache sizable quantities of seabirds to survive. No decline in seabird numbers in the 20 years foxes have lived on the island is evident, though such changes would not be easily detectable in view of the absence of standardized estimates of the large populations of burrow-nesters. Marine birds with low reproductive rates may be very seriously affected by additional sources of adult mortality. Petrels and puffins, whose nest-site selection patterns have evolved on islands free of land predators, are particularly vulnerable to foxes; adults of cliff-nesting species are less likely to be preyed on even in areas accessible to foxes. The extirpation by foxes of any seabird species on Baccalieu Island seems unlikely. However, in view of depredations foxes have inflicted on seabird islands (Jones and Byrd 1979) and the apparent lack of alternative prey on Baccalieu, we conclude that systematic efforts should be made to assess the foxes' impact.

The Canadian Coast Guard provided housing on Baccalieu, where E. Blundon, R. Hyde, F. Noonan, P. Rice, and L. Walsh offered hospitality. B. D. Harvey, I. R. Kirkham, and R. Purchase helped in searching the fox cache. K. Brink, I. R. Kirkham, D. Roby, and G. A. Sanger gave helpful criticism and information. Research was supported by NSERC grant A0687 to W. A. M.

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Received 11 July 1980
Accepted 29 January 1981

Twinning and Postpartum Activity in Barren-Ground Caribou (*Rangifer tarandus*)

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McDonald, E. Janet, and Arthur M. Martell. 1981. Twinning and postpartum activity in Barren-ground Caribou (*Rangifer tarandus*). Canadian Field-Naturalist 95(3): 354–355.

On 26 May 1980 twin Caribou calves (*Rangifer tarandus*) were observed on the calving grounds of the Porcupine Caribou herd in the northern Yukon Territory. Postpartum activity of one of the twins was delayed relative to that of the other twin and to that of a single calf born at the same time.

Key Words: Caribou, *Rangifer tarandus*, twinning, calving.

Twin calves have not been reported in wild Caribou (*Rangifer tarandus*) although twin fetuses have been found (Shoesmith 1976) and twins have been born to captive Caribou (McEwan 1971) and to semi-domesticated Reindeer (also *R. tarandus*) (Nowosad 1973). On 26 May 1980 twin calves were observed in the northern Yukon Territory (69°26′N, 140°46′W) during investigations on the calving grounds of the Porcupine Caribou herd. Weather was sunny and warm (15–19°C) with a light NE wind (21 km/h). From 09:24 to 14:32 solar time, about 500 Caribou in seven loose bands of about 40–150 animals were under observation as they moved northwest across a gently rolling cotton grass (*Eriophorum vaginatum*) meadow. They were mainly cows (97% of the cows were antlered) although about 50 yearlings and 3–5 calves were present. Between 13:54 and 14:09 a band of 123 animals broke up; 56 remained in the area, 50 moved northwest and out of sight, and 17 (11 antlered cows, 1 unantlered cow, 5 yearlings) moved north and downslope to a flat alluvial herb heath which was about 25% snow covered and 15% melt puddles. They began to lie down and, at 14:24, all 17 were lying when continuous observations began on an antlered cow (A) of that group that appeared to be in labor. Eight minutes later, after repeatedly lying down and standing up, she gave birth while standing within the closely spaced band of Caribou (5–10 m between individuals). Although attention was focused on that cow and her calf, a second antlered cow (B), about 10 m away, was in the same field of the scope and, 12 min later, gave birth while standing. Cow B then lay down and did not stand up again for 2 h. Cow B's calf was smaller than cow A's calf. Cow B's body patly obscured her calf and, at times, the heads of two calves appeared to be visible behind her body. The presence of a second calf with cow B was not confirmed, however, until 2 h after the observed birth when she and one calf stood up exposing to view a second, much smaller and wetter appearing calf lying beside the first.

Continuous observations were made by a two-person team, an observer and a recorder. The nature of continuous observations is such that essentially all of the observer's attention was given to the focal animal, in this case cow A. Therefore, the activities of other animals in the field of the scope are recorded only generally, as they relate to the focal animal, and some short-term, unrelated activities may be missed. The recorder, however, was able to scan the other animals periodically. In this case, observations were normally made 15× at a distance of about 350 m, giving a field of view of about 18 m. Cow B was the only other animal in the field of the scope up to the time that the twins were confirmed, and no other Caribou in the group were observed either to be in labor or to give birth.

At 120 min after the observed birth, the larger twin stood up, walked 5 m, and lay down. Cow B followed and lay down beside the larger twin while the smaller twin remained lying and made only a few small movements. The larger twin stood up again about 180 min after the observed birth, walked back, and lay down beside the smaller twin. Again cow B followed and then lay down beside both calves. Following that move the smaller twin began to move its head and body and got up on two legs. Cow B was attentive to both twins and frequently licked their bodies and anuses. During the first 326 min following calving, cow B stood up only four times, twice to follow her calf and twice to stand for less than 1 min each. Cow A, on the other hand, lay down, stood up, walked, and fed repeatedly during the first 338 min following calving. Neither of the twin calves attempted to nurse, whereas cow A's calf nursed 31 times for a total of 12 min 26 s ($\bar{x} = 24 \pm 4.2$ s) during the 171 min from the beginning of the first successful nursing. Com-

pared to the single calf, it appears unusual that neither of the twins nursed during the first 326 min following birth, although the first successful nursing in Reindeer may not take place until 5–6 h after the birth (Baskin 1970).

Cow A passed the placenta while standing 32 min after giving birth and began eating the placenta 134 min later. Cow B passed the placenta while lying 35 min after giving birth and began eating the placenta 158 min later. Times from birth for the first observations of several postpartum activities for cow A's calf are as follows: got up on two legs and dropped down again, 9 min; got up on four legs and dropped down again repeatedly, 22 min; stood on four legs for a short while (8 s), 40 min; attempted to nurse, 50 min; stood for 2 min, 84 min; walked and ran around cow, 98 min; walked for 2 min, 117 min; nursed successfully, 167 min. Those times are similar to times reported previously (de Vos 1960; Kelsall 1957, 1960; Lent 1966; J. Curatolo and D. Roseneau, unpublished observations). They are consistent with those observations that the larger twin stood and walked at 120 min after birth but it is unusual that the smaller twin did not even successfully stand up on four legs during the 206 min after its presence was confirmed.

Observations were terminated at 20:11 because of fatigue, cold, and hunger. When the observers returned 24 h later, six cows, five calves, and an abandoned calf were present on the site. The abandoned calf appeared to be too large to be either of the twin calves. The observers returned again 12 h after the previous check and observed five cows, five calves, and an abandoned calf on the site. Those animals were presumed to be the same group seen at the previous check. The cows and calves moved off to the northwest at that time when another band of Caribou moved through. The site was then thoroughly searched for dead calves but none were found. Possibly both twins left with cow B during the first day after birth or the weaker twin may have been removed by a scavenger. A Wolverine (*Gulo gulo*) was seen near the site on 28 May. Grizzly Bears (*Ursus arctos*) are common in the area but none were seen near the site.

Acknowledgments

We are grateful to Polar Continental Shelf Project, Western Arctic Scientific Resources Centre, and Yukon Wildlife Branch for their support. We thank K. Asquith, C. McEwan, and W. Nixon for their assistance with the field work, and D. R. Flook and D. R. Klein for their comments on the manuscript.

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Received 13 November 1980
Accepted 20 February 1981

Seasonal Pelage Change of Marten (*Martes a. americana*) in Maine

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Soutiere, Edward C., and J.Douglas Steventon. 1981. Seasonal pelage change of Marten (*Martes a. americana*) in Maine. Canadian Field-Naturalist 95(3): 356

The twice yearly molt and seasonal coat color of Marten (*Martes a. americana*) in Maine is documented. The summer pelage is dark whereas the winter pelage is usually paler with reddish-yellow hues predominating.

Key Words: Marten, *Martes a. americana*; pelage color, molt.

The pelage color of Marten (*Martes a. americana*) has been described as being highly variable. Seton (1929, p. 482) stated that the general color ranges from golden yellow to blackish umber. These color variants are described as not being related to the seasonal molt; the summer coat not differing greatly in color from that of the winter coat (Seton 1929; Jackson 1961, p. 328). While live-trapping Marten in the Moosehead Lake and northern Aroostook County regions of northern Maine from 1974 to 1979, we noticed that, much like the Ermine (*Mustela erminea*), the Marten's pelage color is distinctly different in summer and winter.

We use the Munsell system (United States Department of Agriculture 1951) to specify and identify pelage colors. For example, R4/14 means that the hue is red, the value is 4, and its chroma is 14.

We handled 211 individual Marten of which 63 were observed through one or more molts. The pattern and timing of fur replacement followed that described for the European Pine Marten (*Martes martes*) by Schmidt (1943). The molt into the summer pelage begins in late April and is complete by mid-June. The body color of Marten captured during summer ($N = 71$) is very dark grayish brown (10YR3/2) or black (10YR2/1) while the tail is lighter (10YR4/3), tipped with black. The throat patch is reddish yellow (7.5YR7/8).

The molt to winter coat is complete by mid-October in northern Maine. In contrast to the dark summer pelage, the winter coat includes a grayish head and neck and a body color suggestive of a Red Fox (*Vulpes vulpes*). The body color is variable both on and between individuals. The predominant colors of winter Marten ($N = 176$) are yellowish red (5YR5/8), strong brown (7.5YR5/8), reddish yellow (7.5YR6/8), yellowish brown (10YR5/6), and brownish yellow (10YR6/6). The head, neck, and occasionally the fore shoulders are light gray (10YR7/1) or very pale brown (10YR8/4). The color of the legs and tail gradates from the body color to a very dark brown (10YR2/2) on the feet and tip, respectively. The throat patch is reddish yellow (7.5YR7/8) or yellow (10YR8/6).

Two specimens exemplifying the extremes of winter color are filed in the Wildlife Resources Museum, University of Maine. One skin (Catalogue No. 73-2) is dark brown (10YR3/3) with a very dark brown (10YR2/2) stripe along the back from the neck to root of tail. This specimen has a white throat patch (10YR8/2). The second skin (Catalogue No. 276) is nearly white (10YR8/1) except for the legs and tail which are dusky red (10YR3/2). In Ontario, de Vos (1952, pp. 21–25) described Marten in winter pelage as ranging from very pale yellow, a partly albinistic type, to very dark blackish-brown. He made no reference to color variation associated with the seasonal molt.

Of 1055 pelts we examined at fur buyers in Maine, only 2.4% were the dark brown color variant, and 0.7% the nearly white variant. It is clear that in Maine the reddish-yellow winter pelage described is most common and the dark brown or white Marten, such as the museum specimens described or those described by de Vos, are rare.

We thank Art Soukkala, Kate Wynne, and John Major for providing some of the live-trapping data and assisting in examination of pelts. We also thank the fur buyers who allowed access to pelts. M. W. Coulter reviewed the manuscript. Most of this study was conducted during research supported by the School of Forest Resources, University of Maine; the Penobscot County Conservation Association; and McIntire–Stennis Research Project ME-09606.

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Received 5 January 1981
Accepted 4 March 1981.

Marsh Nesting of Common Loons (*Gavia immer*)

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Alvo, Robert. 1981. Marsh nesting of Common Loons (*Gavia immer*). Canadian Field-Naturalist 95(3): 357

The results of a survey conducted on four lakes on the Rideau Canal System, southern Ontario, showed that 58% of the nests of Common Loons (*Gavia immer*) were in marshes. This nest site choice may be attributable to the high levels of human disturbance on these lakes. This finding has implications both for loon and marsh conservation.

Key Words: Common Loon, *Gavia immer*; nest site, island, marsh, human activity.

The Common Loon (*Gavia immer*) is a summer resident of lakes in northern United States and most of Canada. Olson and Marshall (1952), Vermeer (1973), and McIntyre (1975) reported that 93, 96, and 88% of the loon nests that they found were on islands. According to Vermeer (1973), island nesting probably reduces predation; mainland sites are avoided because of their vulnerability to mammalian predators. However, when islands are not present, loons usually nest in marshes (Munro 1945).

The loon's habit of nesting close to the water's edge makes the nest especially susceptible to disturbance by humans. The presence of cottagers and boats often keeps loons off their nests during the incubation period, and may ultimately affect nest site selection. All of the published studies on Common Loon nesting preferences have been conducted in relatively undisturbed areas. The present study was undertaken in a disturbed area to determine whether nest site selection may be affected by human activity.

Study Area

Four lakes (Clear, Indian, Opinicon, and Sand) in the Canadian Shield (44°33'N, 76°20'W), 40–60 km north of Kingston, Ontario, varying in area from 1.72 to 7.86 km^2, served as the study area. The lakes are mesotrophic to eutrophic. Cottage density varies from 16.5 to 43.2 cottages/km^2 of lake area. All four lakes are on the Rideau Canal System and therefore have a large amount of boat traffic during the summer. There is also much fishing, sailing, and waterskiing on these lakes.

Methods

A survey of nesting loons was carried out by canoe 2 May – 31 August, 1980. Nests found were checked every 1 or 2 wk to determine the outcome of each. Hatching success was based on the observation of at least one chick.

Results and Discussion

Of 17 nests found, 7 were situated on islands and 10 were in marshes. Islands with flat sections of shoreline, which would have provided suitable nesting sites, were present near all marsh nests. However, in each of these cases the potential nesting islands were closer to cottages and to the main routes of boat travel than was the marsh site; marsh nests were generally at least 100 m from cottages and from boat traffic, while the potential nesting islands usually were located beside routes of boat traffic and within 50 m of the nearest cottage. The areas with marsh nests were generally very shallow, the nest usually being situated in water about 0.5 m deep; boats were thus very seldom observed in these areas.

Four of 10 marsh nests were successful, compared to 2 out of 7 island nests. The sample sizes are too small to compare the success rates in different situations statistically.

Olson and Marshall (1952) suggested that human activity may influence the selection of nest sites by loons. I suggest that loons in developed areas are giving up their favored island nesting sites to escape such disturbance, and as a result marsh nesting may be increasing in frequency. The small number of sheltered marshy bays may impose a limit to the number of breeding pairs of loons on a lake. All of this adds to the importance of marsh conservation.

Acknowledgments

This work was funded by an Experience '80 grant to Raleigh Robertson. I thank Barbara Black for her kind help. Frank Phelan, Raleigh Robertson, and Steve Dukoff offered invaluable editorial assistance.

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Received 29 December 1980
Accepted 1 March 1981

Evidence of Arctic Grayling (*Thymallus arcticus*) Spawning in a Highway Culvert

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Kratt, L. F. 1981. Evidence of Arctic Grayling (*Thymallus arcticus*) spawning in a highway culvert. Canadian Field-Naturalist 95(3): 358.

Arctic Grayling (*Thymallus arcticus*) eggs were collected in gravel deposits within a circular highway culvert. Because gravel at stream crossings may provide a suitable spawning substrate where none existed before, this alteration is a beneficial effect of road construction.

Key Words: Arctic Grayling, *Thymallus arcticus*; spawning, culverts, road construction, Yukon Territory.

During a fisheries study in the spring of 1980 in southern Yukon Territory, several potential Arctic Grayling (*Thymallus arcticus*) spawning streams were examined. In addition to direct observations of reproductive behavior, evidence of spawning was gathered by checking areas of suitable substrate for the presence of eggs. Samples were collected by holding the edge of a fine-mesh dip net to the stream bottom at a right angle to the current and stirring the area immediately upstream with a stick. In this manner eggs were dislodged and were swept into the net. I employed this technique successfully during previous Arctic Grayling early life history studies (Kratt and Smith 1977).

The construction and maintenance of the Alaska Highway have resulted in gravel deposits at many stream crossing locations. These deposits provide suitable spawning areas in creeks which would normally not be utilized by Arctic Grayling for reproductive purposes. One such stream drains a small muskeg area before flowing into the Koidern River (61°58′N, 140°25′W). Surveys of this stream in 1980 were designed to determine if the creek had again been utilized by Arctic Grayling; hence, efforts were concentrated on locating eggs within the substrate.

On 28 May, Arctic Grayling eggs were found in pockets of gravel located upstream and downstream of the road crossing. Eggs were also collected in a small sand and gravel deposit within the culvert. Because the stream culvert is of the circular variety, substrate materials undoubtedly originated in upstream areas and were deposited by the current.

I assumed that eggs were laid in the culvert because no eggs were observed on the surface of the gravel substrate in any area or were evident in the stream drift. Despite the absence of nest-building behavior, Arctic Grayling eggs are deposited at a substrate depth of 2 to 3 cm (Kratt and Smith 1977). Eggs dislodged from upstream spawning sites would likely pass through the culvert as they remain adhesive for only a short period of time after spawning (Bishop 1971; personal observations).

Guidelines for the protection of aquatic habitats frequently suggest the use of open-bottom culverts for road developments as stream substrates remain relatively undisturbed and disruption of fish passage is minimized (e.g., Dane 1978; Dryden and Stein 1975; Metsker 1970). Although I support these recommendations, the data presented here indicate that materials deposited within closed culverts may also be of importance where available spawning habitat is limited. Thus in some circumstances road construction materials may enhance aquatic habitats.

I thank Foothills Pipe Lines (Yukon) Ltd. for permission to publish this manuscript.

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Received 14 January 1981
Accepted 5 March 1981

Freshwater Fishes from Northern Newfoundland

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Rombough, Peter J., Stephen E. Barbour, and Joseph J. Kerekes. 1981. Freshwater fishes from northern Newfoundland. Canadian Field-Naturalist 95(3): 359–361.

Atlantic Salmon, *Salmo salar;* Brook Trout, *Salvelinus fontinalis;* Arctic Char, *Salvelinus alpinus;* Rainbow Smelt, *Osmerus mordax*; American Eel, *Anguilla rostrata*; Threespine Stickleback, *Gasterosteus aculeatus*; Fourspine Sticleback, *Apeltes quadracus*; and Ninespine Stickleback, *Pungitius pungitius*, were the only freshwater fishes collected from three ponds in L'Anse aux Meadows National Historic Park at the northern tip of insular Newfoundland. The record of the Fourspine Stickleback extends its known range northward by 45 km.

Key Words: *Salmo salar, Salvelinus fontinalis, Salvelinus alpinus, Osmerus mordax, Anguilla rostrata, Gasterosteus aculeatus, Apeltes quadracus, Pungitius pungitius*, L'Anse aux Meadows National Historic Park, Newfoundland, records, range extension.

The Great Northern Peninsula of Newfoundland is the closest part of the island to mainland North America. Garside (1970) and Dadswell (1972) raised the possibility that it may have served as an avenue for the invasion of freshwater fish from the mainland following the Wisconsin glaciation. The freshwater fish fauna of the peninsula is therefore potentially important in the zoogeography of the island but has been only cursorily examined. Van Vliet (1970) surveyed several streams throughout the peninsula, but always within estuarine influences. Dadswell (1972) sampled freshwater ponds in Gros Morne National Park near the base of the peninsula. The present study, to our knowledge, is the first intensive sampling of freshwaters near its northern tip.

L'Anse aux Meadows National Historic Park is located on the Strait of Belle Isle near the northern extremity of the island of Newfoundland (51°35′N, 55°30′W). Three ponds in the park, each in a separate watershed, were surveyed from 6 to 26 August 1977

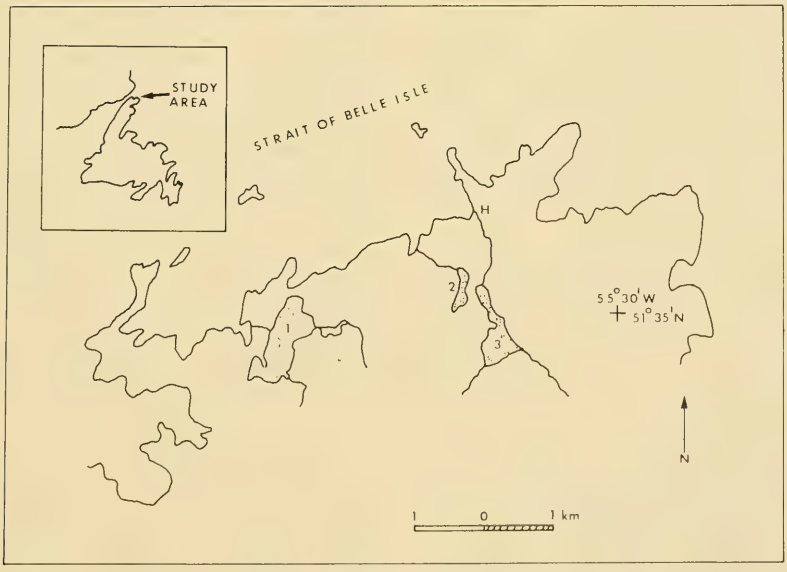

FIGURE 1. Location of the three ponds surveyed in L'Anse aux Meadows National Historic Park on the Great Northern Peninsula of Newfoundland. 1, Duck Pond; 2, Skin Pond; 3, Black Duck Pond; H, Historic Site.

TABLE 1—Physical and chemical characteristics of the ponds sampled in L'Anse aux Meadows National Historic Park, Newfoundland

	Black Duck Pond	Skin Pond	Duck Pond
Surface area (ha)	29.4	7.4	55.2
Maximum Depth (m)	16	1.1	2.4
Mean Depth (m)	4.5	—	1.2
pH	6.5	6.7	6.7
Conductance (μS/cm)	54	42	52
Temperature (°C)	11–17	12	11
Color (Hazen Units)	65	60	120
Predominant bottom type	Rubble, gravel	Mud, sand	Sand, mud

and 8 to 17 August 1978. The ponds were all situated on the coastal barrens within 1 km of the sea (Figure 1). They were relatively shallow, unstratified in August, and highly colored. The physical and chemical characteristics of the ponds are summarized in Table 1.

Samples were collected using variable-mesh gill nets (2.5–7.5 cm stretched mesh) and fine-mesh trap nets (0.5–1.0 cm stretched mesh). Representatives of each species were preserved and stored in the Department of Biology, Dalhousie University.

The species diversity of the freshwater fish fauna of L'Anse aux Meadows National Historic Park (Table 2) is impoverished compared with more southern areas of Newfoundland. Only 8 of the 23 species recorded in Newfoundland freshwaters (Scott and Crossman 1964) were collected in the Park. Although two adult Arctic Char, *Salvelinus alpinus*, were captured in Black Duck Pond in 1977, a resident population is unlikely because no adults were captured in 1978 or juveniles in either year. The fish captured in 1977 were probably strays from rivers that enter nearby Pistolet Bay and are known to contain Arctic char.

Rainbow Smelt, *Osmerus mordax*, and American Eel, *Anguilla rostrata*, were common in Black Duck Pond and Duck Pond. However, Jeffers (1932) reported that according to the local inhabitants both species were rare in the Pistolet Bay region in the late 1920s. These apparently low population levels coincided with low surface water temperatures in the northwest Atlantic. Because this region is near the northern limit of the range of both species, low ocean temperatures may have restricted their numbers. The subsequent warming trend (Lauzier and Hull 1969) may account for their present relative abundance.

The capture of a Fourspine Stickleback, *Apeltes quadracus*, in Duck Pond extends the known range of the species to the northern tip of insular Newfoundland. The previous most northerly record was from brackish water near the mouth of Western Arm Brook, about 120 km southwest (45 km south) of the present location (Van Vliet 1970). The Fourspine Stickleback is typically a marine species but is occasionally found in freshwater (Scott and Crossman 1973; Dadswell 1972). The specimen collected in Duck Pond probably had strayed from the salt marsh at the outlet of Duck Pond Brook.

The present freshwater ichthyofauna of Newfoundland appears to be derived solely from invasions of euryhaline species from the sea. Garside (1970) raised the possibility that unreported populations of obligate freshwater fishes may have become established on the Great Northern Peninsula through migration across the Strait of Belle Isle shortly following the last glacial recession. No obligate freshwater fishes were recorded during our survey of an area along the proposed invasion route, and the possibility that they have become established naturally in insular Newfoundland appears remote.

Acknowledgments

Our thanks are extended to P. G. Daye, A. J. Erskine, E. T. Garside, and S. W. Speller for their helpful comments on the manuscript. Financial support was

TABLE 2—Species and numbers of freshwater fishes captured in ponds in L'Anse aux Meadows National Historic Park in 1977/1978. Plus signs (+) indicate that the species was observed but not captured

	Black Duck Pond	Skin Pond	Duck Pond
Salmo salar, Atlantic salmon	65/43	−/−	−/−
Salvelinus fontinalis, Brook Trout	18/50	36/67	28/13
Salvelinus aplinus, Arctic Char	2/−	−/−	−/−
Osmerus mordax, Rainbow Smelt	12/16	−/−	28/>2000[a]
Anguilla rostrata, American Eel[b]	8/12	−/−	+/+
Gasterosteus aculeatus, Threespine Stickleback	63/>1072	−/−	+/314
Apeltes quadracus, Fourspine Stickleback	−/−	−/−	−/1
Pungitius pungitius, Ninespine Stickleback	−/2	+/199	−/20

[a]Larvae except for two adults.

[b]The presence of a fairly abundant eel population was indicated by damage to gill-netted fish and by the presence of eel marks in gill nets.

provided by Parks Canada and the Canadian Wildlife Service.

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Received 16 January 1978
Revision received 17 December 1980
Accepted 10 March 1981

Sightings of the Hop Merchant (*Polygonia comma*) Butterfly on Insular Newfoundland

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Bernard S. Jackson. 1981. Sightings of the Hop Merchant (*Polygonia comma*) butterfly on insular Newfoundland. Canadian Field-Naturalist 95(3): 361–362.

The status of the Hop Merchant (*Polygonia comma*) on Insular Newfoundland is undetermined. The controversy as to whether or not this species should be included on the island's list of Macrolepidoptera has been recently revived by the photograph and records of new sightings presented here.

Key Words: Hop Merchant, *Polygonia comma*; insular Newfoundland, Lepidoptera, Nymphalidae, range extension.

The Hop Merchant, *Polygonia comma* (Lepidoptera: Nymphalidae), ranges from the maritime provinces, Anticosti Island, Quebec, and Ontario, southward to North Carolina (in mountains) and westward to Kansas, Nebraska, and Iowa (Klots 1951). Its status in Newfoundland is undetermined. Although Dos Passos (1935) states that he recognized *P. comma* as occurring in southern Newfoundland, he almost immediately corrected this error (Dos Passos 1935).

Krogerus (1954), in his study of Newfoundland Lepidoptera, made no mention of *P. comma*. W. W. Gregory (1975, checklist of the butterflies and skippers of Canada, Lyman Entomological Museum and Research Laboratory, Ste. Anne de Bellevue, Quebec. 44 pp.) included Newfoundland in the range of this species, but recently advises (personal communication, 1980) that he now considers this earlier record doubtful and has dropped this taxon from the revised checklist, shortly to be published. Morris (1980) did not include *P. comma* as occurring in the province.

Because previous records of this species in Newfoundland are unsubstantiated and considered controversial, I have reported new sightings here.

On 23 May 1979 an unidentified butterfly was observed feeding from the flowers of a native Primrose (*Primula laurentiana*) and Leatherleaf (*Chamaedaphne calyculata*) in the Oxen Pond Botanic Park, St. John's, Newfoundland (47°34′N, 52°43′W), and another smaller specimen was briefly observed flying around the same area, simultaneously. Some hours later, one was observed in the same general area, feeding from the flower of a Dandelion (*Taraxacum officinale*) and assumed to be one of the original two sighted.

Because Oxen Pond Botanic Park is a nature reserve, especially for butterflies, neither specimen was collected. However, a close-up Kodachrome transparency (see Figure 1) showing the ventral surface of the wings was sent independently to J. Donald Lafontaine and Eugene G. Monroe, both of the Biosystematics Research Institute, Ottawa. Both identified it as a photograph of *P. comma*.

Howe (1975) has stated that the host plants of this

FIGURE 1. Print from the 35-mm color transparency taken on 23 May 1979 of the butterfly subsequently identified as a Hop Merchant (*Polygonia comma*).

species are hops (*Humulus*), nettle (*Urtica*), false nettle (*Boehemia*), and elm (*Ulmus*); the Stinging Nettle (*Urtica dioica*), Hop (*Humulus lupulus*), and English Elm (*Ulmus procera*) are to be found within the general area of the sightings. False nettle (*Boehemia*) does not occur in Newfoundland.

Of the five species or subspecies of the genus *Polygonia* currently found in Newfoundland, only the Green Comma (*P. faunus*) is reasonably common. All others are uncommon and not readily identifiable in the field.

Both hops and Stinging Nettle are to be found in many Newfoundland outports, especially on the Avalon Peninsula, having originated with the early settlers. English Elm trees also are scattered and well established throughout the city of St. John's. Therefore, in areas where one or more of its host plants are present, the Hop Merchant could occur at a low population level similar to that of other recorded *Polygonia*. Its apparent anonymity could largely be due to the scarcity and difficulty in identifying members of this genus and to the lack of experienced field observers in the area.

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Received 28 November 1980
Accepted 23 March 1981

Application of the Värriö Snow Index to Overwintering North American Barren-Ground Caribou (*Rangifer tarandus arcticus*)

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Pruitt, William O., Fr. 1981. Application of the Värriö Snow Index to overwintering North American Barren-ground Caribou (*Rangifer tarandus arcticus*). Canadian Field-Naturalist 95(3): 363–365.

The Varrio Snow Index (VSI) that I derived to model the wintering activity and movements of feral and domesticated Reindeer in northeastern Finland was used successfully to model the wintering activity and movements of wild North American Barren-ground Caribou (*Rangifer tarandus arcticus*). This index is a potentially useful tool for determining nivally suitable areas for Caribou overwintering.

Key Words: Caribou, Reindeer, snow ecology, Mammalia: Cervidae, winter activity.

During the winter 1957-1958, as part of the Cooperative Caribou Investigation, I studied the api (snow cover of the forest floor; see Pruitt 1979 for terminology related to snow characteristics) of northern Saskatchewan in relation to overwintering Barren-ground Caribou (*Rangifer tarandus arcticus*). Throughout the snow season I established, and sometimes repeated, standard api profiles (Klein et al. 1950) at both forest and lake sites. Most of these profiles were established in February 1958. On the basis of obvious relations in the data, I concluded (Pruitt 1959) that Caribou could detect differences in thickness, hardness, and density of the api, and that there were thresholds to these morphological characteristics that the Caribou did not transgress. Moreover, most of the animals' winter movements could be explained by analysis of api morphology.

Later, after I derived the concept of a Snow Index in relation to the small mammals of the low arctic tundra of the Ogotoruk region in northwestern Alaska (Pruitt 1966), I made several unsuccessful attempts to derive a similar index for my Saskatchewan Caribou observations. It was evident that my 114 api profiles were insufficient to permit such derivation.

The problem remained unsolved until winter 1976–1977 when I was able to establish 460 api profiles in relation to feral Reindeer (*Rangifer tarandus*) at Värriö Subarctic Research Station in northeastern Finland. The number of observations, as well as access to more recent studies such as those by Henshaw (1968), Stardom (1975), and Skogland (1978) enabled me to derive the Värriö Snow Index (VSI) (Pruitt 1979). This resulted from my observation that overwintering *Rangifer* react not only to the gross factors of total thickness, hardness, and density of the api, but to other, more subtle, characteristics as well. A hard layer in the upper half of the api seems to be more important in deterring feeding than a layer of equal hardness in the lower half. Surface hardness is probably more important than any other single characteristic because Caribou test this directly (Pruitt 1979). I combined the characteristics of the api in a variety of trial indices; the combination that best modeled the wintering activity and movements of the feral Reindeer in Salla North Reindeer Association I called the Värriö Snow Index (Pruitt 1979).

$$VSI = (H^{>½}(H_bT_b) + (VT_s) + (H_hT_h)T_{ta} / 1000$$

where $H^{>½}$ = hardness of hardest layer more than halfway between the substrate and the top of the api.

H_bT_b = hardness times thickness of basal layer.

VT_s = vertical hardness of surface times thickness of surface layer.

H_hT_h = hardness times thickness of hardest layer (if not H_bT_b). If basal layer is the hardest then term H_bT_b drops out.

T_{ta} = total thickness of api.

The Saskatchewan data had been stratified into "no Caribou," "occasional Caribou," and "Caribou concentration" on the basis of extensive survey flights (see Pruitt 1959 for definitions of these strata). The data were stratified further into forest sites and, usually, a nearby lake site. The forest profiles in the areas of "Caribou concentration" had hardnesses between 6.5 $g \cdot cm^{-2}$ and 60 $g \cdot cm^{-2}$, densities of 0.13 and 0.20, and thicknesses less than 59 cm. The profiles in the areas of "occasional Caribou" could have hardnesses, densities, and thicknesses in the same range as in the "Caribou concentration" areas, but they also could exceed these limits. The profiles in the "no Caribou" areas could have hardnesses, densities, and thicknesses in the same range as in the "Caribou concentration" and "occasional Caribou" areas; they also could

exceed these limits and, in addition, they could exhibit ice layers or "sigulik" in the profiles.

The Finland data were stratified into "Reindeer feeding" and "no Reindeer feeding." These data are also a time-related series so only portions can be compared directly to the Saskatchewan data.

The purpose of this paper was to document the successful application of the VSI to North American Barren-ground Caribou.

Results

Using the Saskatchewan data I calculated VSI values (Figure 1). All possible pairs proved to be significantly different (one-tailed t-test, $P < 0.05$). The VSIs of api used by Saskatchewan *Rangifer* in February were numerically equivalent to VSIs of api used by Finnish feral Reindeer in mid-November. I had previously shown that the "Reindeer feeding" VSIs of Värriö region api increase until spring (Pruitt 1979). What Saskatchewan *Rangifer* would do in Värriö-type api is an unanswerable question, but it is clear that Finnish feral Reindeer have a significantly greater threshold of sensitivity to the factors encompassed by VSI than do Saskatchewan *Rangifer*.

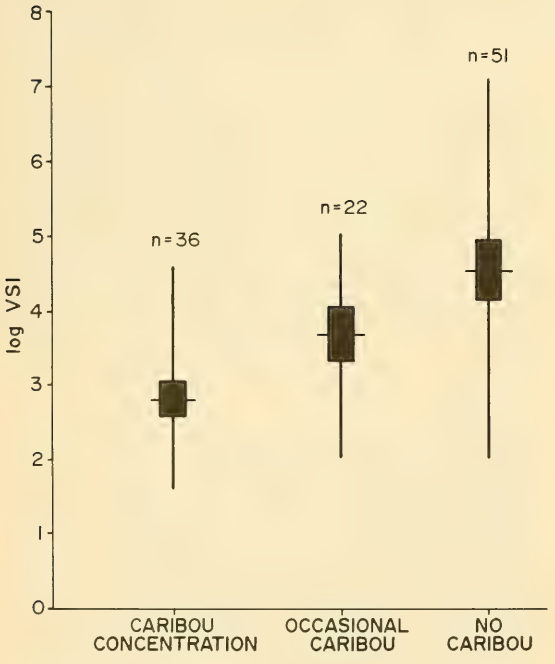

FIGURE 1. Api profiles (log VSI) in northern Saskatchewan, winter 1957–1958, in relation to Caribou distribution: Mean (horizontal lines) ± SD (solid rectangle), range (vertical lines); n, number of Caribou. Note that "Caribou concentration" data indicate that most animals were markedly restricted in their distribution with regard to nival factors.

Discussion

VSI models the api relations of Canadian wild Barren-ground Caribou equally as well as it does those of feral Finnish Reindeer. The differences between Canadian and Finnish api relations are probably the result of artificial selection or culling in Finnish Reindeer. One fundamental precept of domestication is that any Reindeer that tend to "wander" (i.e. instinctively to obey signals of api hardness, density, and thickness) are slaughtered. Even after some thousands of years of artificial selection, contemporary Reindeer still retain measurable reactions to the same api characteristics as their wild relatives.

Up to now it was not known whether discrepancies between thresholds reported for North American wild Caribou and Eurasian Reindeer (Nasimovich 1955; Skogland 1978) were artifacts of different instrumentation and methods or indications of an actual biological difference. According to my comparison of VSIs the difference between Saskatchewan and Finland *Rangifer*–api relations appears to be real. Indeed, this difference can be viewed as a measure of amount of domestication or departure from the wild type. Because api conditions in Finland are not typical of all of the range of Eurasian *Rangifer*, a logical next step would be to extend the comparison to include Old World wild tundra Reindeer. One can conclude, however, that VSI is potentially a useful tool in determining nivally suitable areas for Caribou overwintering.

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Received 19 November 1980
Accepted 4 March 1981

First Canadian Record of Bering Cisco (*Coregonus laurettae*) from the Yukon River at Dawson, Yukon Territory

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deGraaf, Dirk A. 1981. First Canadian record of Bering Cisco (*Coregonus laurettae*) from the Yukon River at Dawson Yukon Territory. Canadian Field-Naturalist 95(3): 365

A Bering Cisco (*Coregonus laurettae*) was captured in the Yukon River at Dawson. This constitutes the first record of this species in Canadian waters and a range extension of 500 km upstream.

Key Words: *Coregonus laurettae*, Bering Cisco; Yukon River, range extension.

On 21 September 1977 a specimen of Bering Cisco (*Coregonus laurettae*) was captured by gill net during fish inventory studies in the Yukon River at Dawson. This constitutes the first record of the species in Canadian waters and a range extension of 500 km upstream in the Yukon River from previously recorded catches at Fort Yukon (Alt 1973). The specimen was catalogued (NMC 77-1771) at the National Museum of Natural Sciences in Ottawa; D. E. McAllister confirmed the identification.

The specimen was a male with moderately large testes, but it did not appear to be in spawning condition. Proportions and meristics agree with published descriptions (McPhail and Lindsey 1970; Scott and Crossman 1973) except that there are 10 principal anal rays instead of the usual 12 to 14. There were 37 gill rakers with 23 on the lower arch; an X ray showed 62 vertebrae including the urostyle. Its total length was 350 mm and the standard length 306 mm, which is near the maximum size (36 cm) reported by McPhail and Lindsey (1970), but well within the range of up to 475 mm reported at Alt (1973).

The biology of this species has not been described in any detail in the published literature; the only account since McPhail (1966) established that they were sufficiently distinct from Arctic Cisco (*Coregonus autumnalis*) to warrant species status is by Alt (1973). Bering Cisco approaching spawning condition were captured from the Yukon River, Alaska, near the mouths of both Hess Creek and the Notwitna River during early and mid-June; the run peaked at Rampart in early September (Alt 1973). Relatively large catches were also reported from a fish wheel at Fort Yukon in late August. The data of Alt (1973) and this record suggest that Bering Cisco probably spawn in the main stem Yukon River between Fort Yukon, Alaska, and the Canadian border.

If substantial numbers of Bering Cisco penetrated the Yukon River system as far as Dawson on a regular basis, they would probably occur regularly in fish wheels operated between Dawson and the Alaskan border, though, because of their size, not in salmon or whitefish nets. A small catch by fish wheel operators would probably not be noted because some salmon fishermen questioned referred to all coregonids as "inconnu" and routinely discarded them.

This range extension resulted from impact-related studies funded by Foothills Pipe Lines (Yukon) Ltd.

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Received 26 September 1980
Accepted 26 January 1981

Reports of Significant Range Extensions

Sharp-shinned Hawk, *Accipiter striatus* (Accipitriformes: Accipitridae) on Victoria Island, Northwest Territories

Holman, Northwest Territories (70°43′N, 117°30′W) early November 1979, in the village.

The bird was captured inside a garage by a local Inuk hunter. The live bird appeared to be blind in one eye at the time of capture. It was killed, photographed, kept frozen, and later given to me. Unfortunately, the specimen was lost in shipment to our laboratory; thus the sex was not determined.

Two photographic slides of the specimen are on file in the Ornithology Section, National Museum of Natural Sciences, Ottawa. Confirmation of the identification was made by W. Earl Godfrey, Curator Emeritus of Ornithology.

Sharp-shinned Hawks are known to breed in the northern Yukon and southern District of Mackenzie but have not been recorded as accidentals in the Canadian arctic islands. This constitutes an extension of 947 km in a direction of 56°97′ from the nearest record at Old Crow, Yukon Territory.

THOMAS G. SMITH

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Received 11 July 1980
Accepted 1 March 1981

Two-lined Salamander, *Eurycea bislineata* (Amphibia: Caudata: Plethodontidae), in Labrador

Cache River tributary, Labrador, Province of Newfoundland (53°12′N, 62°16′W), 16 August 1979.

Several larval Two-lined Salamanders were captured by electrofishing during a baseline population study of Brook Trout (*Salvelinus fontinalis*). The stream followed a deeply incised valley in open Black Spruce (*Picea mariana*) lichen forest, which is typical of the Labrador Plateau. At the collection site, situated 100 m downstream of a small lake, the stream was 3.9 m wide, the mean depth was 0.14 m, and the mean cross-section water velocity was 0.3 m/s. The stream substrate consisted of boulders and rock rubble, most of which were covered with aquatic mosses. The site was shaded by overhanging alders (*Alnus* spp.), willows (*Salix* spp.), and Black Spruce. At the time of collection water temperature was 14°C, dissolved oxygen 8 mg/L, pH 4.76, and specific conductance 14 μS/cm; these conditions are similar to those of other streams in the area (Jamieson 1979). Such low specific conductance is generally associated with low biological productivity (Ryder et al. 1974) which was further evidenced by a sparse benthos (122.0 animals/m^2). Despite the indications of low productivity, the population of Brook Trout at this site was relatively high (39.4 fish/100 m^2) when compared with other sites in Newfoundland and Labrador. Most of the trout were smaller than 100 mm (fork length). The only other fish species captured in this stream was Lake Chub (*Couesius plumbeus*).

The only previous record of a Two-lined Salamander from Labrador was a juvenile found near Labrador City (Cook and Preston 1979), over 250 km W of the Cache River site. Based on verbal reports of a small salamander in the Lake Melville region (Bleakney 1958), Cook and Preston (1979) hypothesized the existence of the Two-lined Salamander in central and eastern Labrador. Another species, the Blue-spotted Salamander (*Ambystoma laterale*), is known from the Goose Bay area (Cook and Folinsbee 1975). Although the Lake Melville salamanders could be either species, our record supports the suggestion by Cook and Preston (1979) that the Two-lined Salamander has a wider Labrador range than their single specimen indicated.

One specimen was retained for identification and has been deposited in the National Museum of Natural Sciences, Ottawa, Canada; catalogue number NMC 20562. This larva was 61 mm in total length and 30 mm from snout to the anterior margin of the vent.

We acknowledge the Lower Churchill Development Corporation Ltd. which funded the aquatic

investigations resulting in the collection of the specimen.

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Received 22 September 1980
Accepted 28 January 1981

News and Comment

John M. Powell — Honoured

The sixth annual Loran L. Goulden Memorial Award for outstanding contributions to natural history in Alberta was awarded to John M. Powell of the Northern Forestry Research Centre, Edmonton, at the Annual General Meeting of the Edmonton Natural History Club on 13 January 1981. Dr. Powell is a well-rounded naturalist, who has published on such diverse areas of nature study as climatology, botany, entomology, ornithology, mammalogy, and history of naturalists. He was particularly recognized in this award for his outstanding dedication to the Federation of Alberta Naturalists (FAN) and its corporate member clubs, having served as FAN's first Secretary, third President, and a continuous board member in FAN's 10-yr history, and also as a former President of the Calgary Field Naturalists and Director of the Edmonton Natural History Club. He has also represented FAN on various government committees. A biography of John M. Powell by Charles D. Bird will appear in the forthcoming history of the Federation of Alberta Naturalists and its corporate member clubs, and his publications will be listed in the March 1981 issue of the *Alberta Naturalist*.

MARTIN K. MCNICHOLL

Chairman, Loran L. Goulden Memorial Award Committee

Report on New Titles of Books

The year 1980 (volume 94) was rather successful for the book review section of *The Canadian Field-Naturalist*. The number of reviews published, 48, was down from 1979, but greater than 1978. However, 70 reviews were completed and submitted for publication, which will mean a significant increase in 1981. This trend should continue because 67 books were sent to reviewers. The 93 complimentary New Titles received from publishers represents a substantial increase over previous years indicating either an increase in natural history literature or in the reputation of our journal.

Authoritative book reviewers are always in demand. Persons are especially needed to review New Titles listed as available, but the Book Review Editor will make every effort to obtain review copies of other appropriate titles that are requested by prospective reviewers. Further information and guidelines for preparation of reviews can be obtained by contacting Dr. Wilson Eedy, Book Review Editor, R.R. 1, Moffat, Ontario L0P 1J0.

Request for Information — Marked Snowy Owls

Since 1977 I have banded over 60 Snowy Owls wintering in the Duluth, Minnesota harbor area. Owls were individually marked with black dye on wrists, wing, and/or tail feathers, and fitted with a green patagial wing tag with white letter–number combination on the right wing. Fifteen of 32 owls banded in 1978–1979 and 1979–1980 returned to the harbor study area in subsequent winters. Observers are asked to look for and report any marked owls seen, especially breeding owls. Where feasible, banding of marked owl's young would be greatly appreciated. Reports should include place, date, color marks (may be quite faded), and wing tag number, general habitat, evidence of breeding, and abundance of small mammal prey. Adult females occupying adjacent winter territories have returned to occupy adjacent territories in subsequent winters; they may be breeding in the same locality. All reports will be acknowledged and should be sent to: *David L. Evans, 2928 Greysolon Road, Duluth, Minnesota 55812* (218-724-0261) and to the *Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Maryland 20811.*

Restoration and Management Notes

Free copies of the first issue of *Restoration and Management Notes,* a new publication from the University of Wisconsin-Madison Arboretum, will be available to interested persons on request. The publication, to be made up mostly of short notices dealing with the techniques and principles of restoring and managing communities of native plants and animals, is intended to encourage communication between researchers, managers, naturalists, landowners, and others involved in the active conservation of natural and semi-natural areas. The first issue is scheduled for publication in April 1981. Those interested in receiving a complimentary copy are invited to contact Dr. W.R. Jordan, III, The University of Wisconsin-Madison Arboretum, 1207 Seminole Highway, Madison, Wisconsin 53711. (608) 263-7888.

Notice of Motions to Amend the Constitution of The Ottawa Field-Naturalists' Club

Notice of four motions to amend the Constitution of The Ottawa Field-Naturalists' Club was received in accordance with Article 23 of the Constitution, for presentation at the next Annual Business Meeting. It is proposed that:

Article 8 now reading:

> "OFFICERS. The officers of the Club shall be a President, a Vice-President, a Recording Secretary, a Corresponding Secretary, and a Treasurer."

be amended to read as follows:

> OFFICERS. The officers of the Club shall be a President, a First Vice-President, a Second Vice-President, a Recording Secretary, a Corresponding Secretary, and a Treasurer.

Article 10, now reading:

> "STANDING COMMITTEES. Four standing committees, each consisting of at least five members, shall be appointed by the Council, namely: a Publications Committee, an Excursions and Lectures Committee, a Finance Committee, and a Membership Committee. The Chairman of each standing committee shall be chosen from among the members of the Council. The Editor of *The Canadian Field-Naturalist* and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Publications Committee. The Vice-President, the Treasurer and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Finance Committee. The Chairmen of the Excursions and Lectures Committee and the Membership Committee shall have power to add to their Committees."

be amended to read as follows:

> STANDING COMMITTEES. Six standing committees, each consisting of at least six members, shall be appointed by the Council, namely: an Executive Committee, a Publications Committee, an Excursions and Lectures Committee, a Finance Committee, a Conservation Committee, and a Membership Committee. The Chairman of the Executive Committee shall be the President. The Chairman of each other standing committee shall be chosen from among the members of the Council.
>
> Both Vice-Presidents and the Recording Secretary shall be members of the Executive Committee. The membership of each standing committee shall contain at least one of the Vice-Presidents. The Treasurer and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Finance Committee. The Editor of *The Canadian Field-Naturalist* and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Publications Committee. The Chairmen of the Excursions and Lectures Committee, the Conservation Committee, and the Membership Committee shall have power to add to their Committees.

Article 17, now reading:

> "DUTIES OF THE VICE-PRESIDENT. In the absence of the President, or at his request, the Vice-President shall act in his stead. The Vice-President shall be a member of the Finance Committee."

be amended to read as follows:

> DUTIES OF THE VICE-PRESIDENTS. In the absence of the President, or at his request, either the First or Second Vice-President shall act in his stead. Both Vice-Presidents shall be members of the Executive Committee. The membership of each standing committee shall contain at least one of the Vice-Presidents.

Article 18, now reading:

> "DUTIES OF THE RECORDING SECRETARY. The Recording Secretary shall keep minutes of the proceedings of the Council, the Annual Business

Meeting and Special Business Meetings. He shall give previous notice to each member of the Council of its meeting and to the general membership of the Annual Business and Special Business Meetings. He shall be the custodian of the Constitution and the By-laws and of the records of the Club. He shall be the compiler of the Annual Report of the Council and shall make it available to the General Membership at the Annual Business Meeting. He shall receive and deal with proposed motions to amend the constitution pursuant to Article 23."

be amended to read as follows:

DUTIES OF THE RECORDING SECRETARY. The Recording Secretary shall keep minutes of the proceedings of the Council, the Annual Business Meeting, and Special Business Meetings. He shall give previous notice to each member of the Council of its meeting and to the general membership of the Annual Business and Special Business Meetings. He shall be the custodian of the Constitution and the By-laws and of the records of the Club. He shall be the compiler of the Annual Report of the Council and shall make it available to the General Membership at the Annual Business Meeting. He shall receive and deal with proposed motions to amend the constitution pursuant to Article 23. The Recording Secretary shall be a member of the Executive Committee.

Motions proposed by Daniel F. Brunton, seconded by Paul Catling.

Frank Pope
Recording Secretary

Explanatory Note

There are two basic reasons for proposing these motions. First, the expanding programs and activities of The Ottawa Field-Naturalists' Club are placing a heavy burden on the President and Vice-President and in order to share this workload more equitably, a Second Vice-President position is proposed. The two Vice-Presidents should be considered equal in all respects. Second, it is felt that the important and fundamental roles of the Executive and Conservative Committees in Club activities should be recognized by designating them as standing committees of Council.

Notice of The Ottawa Field-Naturalists' Club Annual Business Meeting

The 103rd Annual Business Meeting of The Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and McLeod Streets, Ottawa, on Tuesday, 12 January 1982, at 20:00.

Frank Pope
Recording Secretary

Call for nomination for the Council of The Ottawa Field-Naturalists' Club

A Nominating Committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1982, as required by the Constitution.

Club members may also nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the Nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5, to arrive no later than 13 November 1981.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 November 1981. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

DANIEL F. BRUNTON
Chairman, Nominating Committee

The Ottawa Field-Naturalists' Club

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Book Reviews

ZOOLOGY

Birds of Pacific Rim National Park

By David F. Hatler, R. Wayne Campbell, and Adrian Dorst. 1978. Occasional Paper Series Number 20. British Columbia Provincial Museum, Victoria. 194 pp., illus. $3.00.

Although Pacific Rim National Park, British Columbia, forms the focal point for this study, the authors chose to work "from an ecological rather than a real estate perspective." The study area thus consists of the west coast of Vancouver Island from Qlayoquot Sound south to Port San Juan, including several pelagic records well beyond sight of the shore. The book begins with a series of short introductory sections, including the history of work on birds in the area, methods of research, and a checklist of 247 bird species "known or strongly suspected" to occur in the park, to which Clark's Nutcracker is added in the Preface. The bulk of the text consists of detailed species accounts, followed by a series of transects at specific places within the park. Several appendices and an index complete this volume.

The species accounts range in length from one paragraph to about four pages. Each documents the status of the species in the park area, often in comparison with its status on other parts of Vancouver Island and/or the lower British Columbia mainland. A chart of the number of records per month is given for many species and serves as a rough guide to seasonal occurrence. Records are based on a combination of historical information, incidental and exploratory observations by 104 observers, and systematic surveys conducted for Parks Canada. General ecology and life history data are included for many species, and anecdotes of behavioral observations are scattered throughout. Species accounts on cormorants, Great Blue Heron, wintering swans, Bald Eagle food and feeding behavior, Osprey, Black Oystercatcher, Glaucous-winged Gull, several alcids, and Northwestern Crow are in sufficient detail that the book should be included in the bibliographic files of any researcher working on these species. Other tidbits of information which may be missed by people not inclined to read local avifaunal works include a comparison between courting behavior of the two goldeneye species, a comparison of the feeding areas of Surf and White-winged Scoters, a record of an apparent hybrid Glaucous-winged × Western Gull, speculation on feeding habits of Chestnut-backed Chickadees, and observations of Starlings apparently copying turnstone feeding methods. Naturalists concerned about their effects on birds should read the account of the Common Merganser for an example of why attempts to "rescue" ducklings separated from the brood are unwise.

When distinct races of a species are found to be conspecific, there is an unfortunate tendency for many observers to stop noting which race they see in particular areas. Therefore, I was pleased to read the authors' differentiation between the breeding and common migrant Audubon's race and the rare migrant Myrtle race of the Yellow-rumped Warbler. The authors also state clearly that Oregon Junco is the race of the Dark-eyed Junco in the park, thus indicating that the Slate-colored has not yet been identified there. An appendix comparing recent names (as used in the book) with those still included in many field guides will be helpful to casual observers.

The transects near the end of the book should prove useful as local bird-finding guides to visiting naturalists. Each contains a table of numbers of each species seen on various dates, plus a map on which is indicated species seen at particular times of the year (or all year) and "special" species sometimes found in the vicinity.

Birds of Pacific Rim National Park is an attractive volume, well written and amply illustrated with both photographs and drawings. Data on many species (especially waterbirds) are more extensive than usually included in local avifaunal works. Inclusion of such data in this book will irritate some researchers who are more likely to overlook some information pertinent to their interests than if the authors had summarized the data in a separate journal publication. On the other hand, inclusion of these facts adds interest to the book and might stimulate lay people to make (or report) further observations. Moreover, the publishing priorities of the three active authors may preclude at least some of these data from ever being published if they were not included in the book.

The book is remarkably error free, but statements in two species' accounts are slightly misleading. In discussing three territorial male Blue Grouse, the authors mention that the females "belonging to them" were not seen, implying at least a temporary pair bond. The best evidence to date, collected also on Vancouver Island, suggests that this species is promiscuous. Observations of Townsend's and Wilson's warblers feeding young Brown-headed Cowbirds are apparently taken as evidence these warblers were the hosts. While this may well be true, non-host adult

birds will sometimes feed demanding young cowbirds, and such observations are not sufficient in themselves to establish the feeding bird as the host. Incidently, Friedmann and his co-workers have compiled two host lists since the one cited (Auk 88: 239-255. 1971; and Smithsonian Contributions to Zoology 235. 1977). To these minor points, I add one additional criticism. The authors use "Hypothetical" status in two ways: both for species identified but without substantiating evidence, and for species expected to occur on the basis of occurrence nearby. The former use is more common, and the latter species would probably have better been relegated to an appendix.

This book is a "must" item on the bookshelves of all west coast ornithologists. Compilers of local avifaunal works elsewhere would do well to use it as a standard. At the low price, it should easily be in the budget for bird-watching visitors to Vancouver Island and for researchers on species for which extensive accounts are included. I recommend it highly.

MARTIN K. MCNICHOLL

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The Alaskan Bird Sketches of Olaus Murie with Excerpts from his Field Notes

Compiled and edited by Margaret Murie. 1979. Alaska Northwest Publishing, Anchorage. 64 pp. illus. (51 paintings). $14.50.

It is difficult to consider just one Murie brother. Both Olaus and Adolph Murie were pioneers in the early days of game management, bridging the time in wild Alaska from the dog sleigh to the snowmobile, and pushing back the frontiers of biological knowledge in such widely separated and wildly different places as the turbulent Aleutians, cold-impoverished Labrador, and islands of wilderness in the south such as Wyoming's Grand Teton Mountains. It was Adolph who, perhaps, published most memorably about the north (*The Wolves of Mount McKinley* in 1944; *A Naturalist in Alaska* in 1961), but his southern contributions were formidable too (*The Moose of Isle Royale* in 1934; *Ecology of the Coyote in Yellowstone* in 1941). Olaus' large and definitive work *The Elk of North America*, published in 1951, is of course "southern," but his first major pioneering work, *Alaska-Yukon Caribou* in 1935, was remarkable for its ecological approach to data gathered along lonely miles behind a dog team. His *Food Habits of the Coyote in Jackson Hole, Wyoming*, published in the same year, is an early example of the geographic dichotomy of interest shared by both brothers. The last major work published by Olaus documents studies done in earlier years. *Fauna of the Aleutian Islands and Alaska Peninsula* was published in 1959.

Olaus Murie was a leader through the early exciting years in wildlife biology, when Aldo Leopold's *Game Management* led the way to "wise use" of wildlife resources, and when a maturing knowledge of ecology combined productively with wildlife biology, the principles of land use, and geographical explorations into mountains still unmapped and along shores still unknown. It was when wildlife management was coming of age; when its leaders were broadly based naturalists and were proud of it. From this base of knowing and loving the land and its life evolved today's more specialized approaches to wildlife research and management.

Olaus Murie died in 1963. His wife, Margaret, survives him, and in the book reviewed here brings together a collection of his bird paintings made in Alaska, many in the Aleutians, through the 1920s and 1930s. Appropriate passages from his field notes of the time accompany the sketches.

The introduction by Margaret Murie puts the times, the places, and the work into context. She is well qualified for the role. At a time when society was not sure that it approved and when life in the wilderness had few of today's comforts, she was usually with Olaus in the field. So too were their children even before they could walk.

This is a book of pictures, all in full color, and the word "sketches" in the title is correctly used. Most are field sketches, the "soft parts" paintings of the thorough ornithologist collecting little known birds, and so usually consisting of head and neck portraits in color accompanied often by a foot and leg in similar detail. The main purpose of such sketches is to catch the fleeting colors of birds that soon fade after death, such as the hues of the bill, eye, bare areas on the head and neck when they occur, and the foot and leg. This need of accurate record is the main incentive to produce such works, but despite the rough to nearly impossible conditions under which they must be executed, they occasionally qualify as superb ornithological portraiture, and more rarely as good art aside from their dedication to visual truth.

The sketches in this book have unusual value, for they feature little known details of Alaskan species of birds still intimately known to few scientists, and to even fewer with active paint brushes. Those of Whiskered Auklet, Crested Auklet, Parakeet Auklet,

Sabine's Gull, downy young of Wandering Tattler, the same of Spectacled Eider, Bristle-thighed Curlew, and Red-faced Cormorant are among the special ones. As a bonus, some to me are high ornithological art, among them the curlew and downy eider mentioned above, and a superb portrait of an immature male Common Eider.

Olaus Murie was a productive and careful scientist with wide interests and many talents. In his later years he was a leading force in the Wilderness Society, and he had much to do with the United States Government's Wilderness Act, brief facts speaking volumes about what he thought important. What he saw and thought and did through his life will be built upon and enjoyed for a very long time. This book of sketches should be followed by other publications based on his journals and papers, for those who know about him, and for many more who will discover him.

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A Bird-Finding Guide to the Toronto Region

By Clive E. Goodwin, 1979. The Toronto Field Naturalists Club, Toronto. V + 97 pp. $2 plus 50¢ postage

This guide is intended for the newcomer to bird watching in the Toronto region, either those coming from other areas or for long-time residents just getting interested in the sport of finding birds.

After an introductory chapter on the plan of the book and abbreviations used in it, there is a chapter on the habitats in the area and their associated bird species, then a chapter on these species indicating when to look for them on a month-by-month basis.

This is followed by several chapters giving helpful directions for finding specific bird sites, from the lakeshore back to the moraine country to the north, with a summary of special associated birds to look for at different seasons. I am personally most familiar with sites in the eastern part of the Toronto region where I found the author's directions to key areas straightforward and the highlights appropriate. The booklet concludes with chapters "for the newcomers" and with a systematic list with the best month and best areas suggested for each species.

This is a sturdy paperback, 6 × 9¾ in. (1 in. = 25.4 mm) with an attractive cover photograph of a Saw-whet Owl. It contains three maps, one of the Halton Region Forest, one of Metropolitan Toronto, and one of the Toronto Region as a whole, each with arrows or numbers showing the general locality of points of particular interest to bird watchers.

The book is meant to be used in conjunction with a good road map of the region, as the maps in the book are not adequate for finding specific areas, even though the written directions are very good with a map in hand. I would have preferred bar-type graphs to show the seasonal occurrence of each bird rather than the method used, but this might have added to the expense of what is now an exceptionally inexpensive guide. A title on the spine of the booklet would have been helpful in locating it on a crowded bookshelf.

This is a very helpful guide for anyone interested in the bird life of the Toronto region.

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The Black Bear in North America

Edited by D. Burk. 1979. Boone and Crockett Club, Alexandria, Virginia. 299 pp. U.S. $10.

This book contains the proceedings of a workshop on the management of the North American Black Bear. The goal of the workshop was threefold: First, to review the state of existing knowledge and the present status of the Black Bear in each state and province in which the species is found; second, to develop policy on all aspects of management; and third, to produce a document that will serve to assist managers and biologists in the planning and decision-making process.

The book is divided into four parts. Part one is a summary of existing knowledge relevant to Black Bear management. There are reports from 37 states, 9 provinces, the Yukon and Northwest Territories, and Mexico. In general, representatives from each jurisdiction endeavored to review habitat, laws and regulations, protection, management, population trends, hunting, public attitudes, and current problems. The

representatives from Michigan presented three papers that dealt with hunting with hounds, age determination from premolar sections, and age determination from cementum annuli. A review of the Black Bear's status was not outlined for Michigan.

It was generally felt that compared to other major wildlife species, knowledge of the Black Bear is presently insufficient to enable biologists to develop suitable management strategies. Many jurisdictions have initiated research and management programs only in the last decade. There is much still left to learn about the Black Bear in Central and North America.

Part two consists of a paper presented by Stephen Herrero of the University of Calgary, entitled "Black Bears — the Grizzlies Replacement." Herrero presents the theory that Black Bears, despite their apparent adaptibility to man and altered habitat, will not succeed the Grizzly Bear in its habitat for evolved morphological and behavioral reasons.

Part three is comprised of the reports from the Pacific, Rocky Mountain, southeast, and central and northeast Canada and the United States working groups. Consideration is given to: habitat, land use, management, hunting, population trends and density, illegal activities, bear-man conflicts, public education, and research needs. Corresponding recommendations are set forth in the text. For example, timber management guidelines designed to protect and enhance Black Bear habitat were submitted by the Pacific working group. They include recommendations that deal with the size, spacing, and frequency of clear cuts, as well as herbicide use, road construction, and access.

Part four, entitled "Final Session Comment," is a dialogue between the participants during which the chairmen summarize the recommendations developed by their respective working groups.

The text is well organized; however, a few of the figures referred to in the text are missing. The book is a useful reference document and is recommended to those involved in Black Bear management.

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The Freshwater Fishes of Alaska

By James E. Morrow. 1980. Alaska Northwest Publishing Company, Box 4-EEE, Anchorage, Alaska. 248 pp., illus. U.S. $29.95 (+ $.75 U.S. Postage and handling).

This in an informative, pleasingly designed, well-illustrated book on the 56 species of fishes occurring in the freshwaters of Alaska. A considerable amount of information is packed into the two and a half (8½ × 11 in.) pages devoted on the average to each species. The text, which is written in readable prose rather than telegraphic statements, should appeal to the angler as well as the scientist, especially as the text's layout and typography is pleasing to the eye.

The book is divided into an introductory section, a key to the families, family and species accounts, a 25-page bibliography, a glossary, and an index. The color photos and illustrated plates are grouped together in the middle of the book. Some color photos are excellent (the elegant spawning livery of the Dolly Varden) while others are based on moribund specimens. The carbon dust illustrations by Marion J. Dalen combine detail, precision, and the spark of life. I care less for her water colors which do not seem to capture the luminosity of live pigments.

A chapter is devoted to each family or subfamily. The chapter usually begins with a key to species and an account of the distinctive morphological and biological features of the family. Important diagnostic characters are often illustrated to help the reader use the keys. The species accounts have the following sections after the common and scientific names: distinctive characters, description, range and abundance, habits, and importance to man. Habits, the longest section, presents an account of the life history of the species. Outline drawings and maps with ranges indicated by cross-hatching are included for most species. The reviewer prefers spot distribution maps for the greater amount of information they convey. Little emphasis is given to systematics.

The book is well edited and there are few typographic and scientific errors. The range of Arctic Charr, however, extends to Alert, northern Ellesmere Island; and Ninespine Stickleback, contrary to several references, are not found in Greenland. The lateral line "pores" of Blackfish and head "pores" of the Arctic Lamprey are instead surface neuromasts. Plate 30D shows eight left and seven right branchiostegals on the coastrange sculpin; normally six are found on each side in this species.

This beautifully designed, informative, and readable book should appeal to the fisherman, naturalist, and biologist. The author, artist, and editor are to be congratulated.

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North American Birds of Prey

By William Marshall. Paintings by Gary Low. 1980. Gage, Toronto. 176 pp., illus. $29.95

North America has had several excellent wildlife artists. Among bird illustrators, there are many superb painters from Audubon to Landsdowne. With the publication of *North American Birds of Prey*, another Canadian seems destined to become a select member of this group.

In this beautiful book, Gary Low has presented 27 full-color paintings of the most common hawks and owls of northeastern North America. Also provided for each species is a baseball-card-like facial portrait. With their penetrating eyes, different beaks, and varied feathering on the face, birds of prey make excellent subjects for these portraits. Low excels in his color pictures. An important decision for a wildlife artist is how purely representative he should be. Roger Tory Peterson's paintings for his field guides are to help us identify birds: they are like pictures. Other artists, Parnell, for example, take considerable liberties with the subject, often producing a symbol rather than a bird. Low demonstrates his ability in both areas. His paintings of the Turkey Vulture, Broad-winged Hawk, and Snowy Owl are superb pictures of these birds. In some of his other paintings, Low dazzles us with something unexpected which jumps out from the picture; the Goshawk about to pounce on a rabbit, the Saw-whet Owl with a kinglet, a Long-eared Owl 'nustled' against a tree. These pictures present more than just bird paintings. My favorite is the picture chosen for the cover: our most common hawk, the Red-tailed Hawk, sitting on a post which is part of an elegant fence.

The only disappointment with the book is with the falcons — to some the essence of avian predators. Unfortunately, all four of the falcons are depicted settled, three on trees and one on a rock. I hope Gary Low will attempt something more daring with these magnificent birds next time.

Each illustration is accompanied by a short text written by William Marshall. Like Low, Marshall faces a choice as well: be very biological and scientific or be informal and 'chatty.' He combines approahces and offers readers insight into the bird's behavior and role. Of special interest are the two back sections, one on falconry and one on pesticides. These are both extremely interesting.

Finally, for each bird depicted there is a food summary at the back of the book, which provides interesting information. It certainly reminds us that the birds we have been looking at are predators.

North American Birds of Prey is a beautiful book both for birders as well as those who appreciate fine paintings. It will be very interesting to watch Gary Low develop as a painter of wildlife. He clearly shows he intends to do more than "hold a mirror up to nature." This is a bold step. His first book launches him well on his journey.

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Wolf and Man: evolution in parallel

Edited by R. L. Hall and H. S. Sharp. 1978. Academic Press, New York. 210 pp., illus. U.S. $22.95.

Wolf and Man, as the title suggests, is a collection of papers on the topic of human–wolf co-evolution. The editors' purpose is clearly to draw a parallel between the adaptive behaviors of humans and wolves. This aim is based on the premise that both humans and wolves evolved as group hunters. Although this hypothesis has appeared reasonable to natural scientists for sometime, to my knowledge this is the first published account of a multidisciplinary analysis of the topic.

The text is organized in a manner that describes the cultural attributes, social features, and history of *Homo* and *Canis*. Part one presents four chapters concerning group behavior of wolf and man as it relates to culture. Specific reference is made to group hunting characteristics. A chapter on Coyote natural history is also included. The following three chapters represent a treatise of wolf communication features and functions as they compare to communicative evolution features in man. The final two chapters examine the paleobiology of dogs and man.

The editors have by and large successfully accomplished their endeavor. There are, however, some areas of assumption made in the text. For example, in the sections on communication, two papers are presented (both previously published) that clearly demonstrate the fact that olfactory and auditory factors (scent, marking, howling) have an indirect communicative function in wolves. This premise seems quite reasonable. The editors next analyze early human forms of visual communication (i.e., interpretation of visual signs) on a comparative basis. It seems more

plausible to assume that these communication features are in fact divergent evolutionary trends.

The comparative analysis of wolf–human group hunting behavior on a cultural basis is somewhat overstated in the text. It is important to realize that internal wolf pack regulatory behaviors are most critical to group hunting characteristics. Therefore, although wolf–human hunting characteristics may be similar (i.e., *Comparative Ethnology of the Wolf and the Chipewyan*), the sociological factors critical to group hunting characteristics in the two generic groups are somewhat variable.

In summary, the editors have done an admirable job of combining the study of behavior from both an organism and social standpoint. This alone makes the text well worth reading. Some areas of the text are superficially treated, such as the chapter on Coyote natural history which lacks current references.

Persons interested in wolf biology from an anthropological perspective will enjoy the complete text. Individuals looking for a biological slant to wolf–human behavioral evolution should seek elsewhere.

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The Squirrels of Canada

By S. E. Woods, Jr. 1980. National Museums of Canada, Ottawa. 200 pp., illus. $29.95.

This book has a pleasing appearance and is well designed and well illustrated, as it should be for the price. The color photographs of each of the 22 species of marmots, ground squirrels, chipmunks, tree squirrels, and flying squirrels discussed are superb, the line drawings evocative (if one ignores the odd perspective of eagle and marmot on page 39). The text runs smoothly and is divided into sections entitled: Names, giving derivations of the common and specific names; Description; Range, accompanied by maps of the Canadian and North American distribution; Behaviour; Personality, incorporating a suitable quote from a naturalist or zoologist; Habitat; Feeding Habits; Life Cycle; Natural Enemies; Relations with humans; and Where to observe. This format is handy for reference and for browsing, but involves much repetition of information between species (we are told six times that *Spermophilus* means "lover of seeds"), and some within a species (such as the timing of hibernation, and information on burrows and populations.)

The text is curiously old-fashioned, referring to all individual animals as "he"; describing the skunk as "more valuable" than the Woodchuck; calling the Yellow-bellied Marmot society a patriarchal one; referring frequently to individuals standing like "picket pins"; and having animals "perform bodily functions" rather than urinate and defecate. There are a number of interesting anecdotes which help to bring the subjects to life.

Unfortunately there are several errors of fact as well as some typographical errors. It is not correct to say that primates other than man walk upright, to generalize that zoologists use muscle arrangements of a rodent's jaw for classification, or to define incisors as only located on the premaxillary bone. I also find it difficult to believe that one could confuse a Red Squirrel and a Fox Squirrel even at a distance, given their different habits and their great difference in size. In connection with size, I should mention here discrepancies in various measurements. A. W. F. Banfield, in *The Mammals of Canada* which is listed in the bibliography, gives the average Red Squirrel weight as about 190 g, while Woods reports 230 g; for the Northern Flying Squirrel, Banfield quotes weights ranging from 75 to 139 g, while Woods gives an average weight of 160 g.

This book is aimed at the layman rather than the professional zoologist. Although a short list of references is included, over one-third are pre-1950 and there are only four original papers cited for the 1970s. None of the data in the text itself is referenced. There is a short glossary, a short index, and a seven-line table of metric conversion figures.

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BOTANY

The Flora of Canada

By H. G. Scoggan. 1978-1979. (Four volumes). Publications in Botany Number 7 (1–4), National Museum of Canada, Ottawa. xiii + 1711 pp. $131.00 (sold only as set).

This massive work sets out to list all species growing without cultivation in Canada. It recognizes 3218 native species and a further 884 aliens, for a total of 4102 species. To provide treatments for each of these and their subspecific taxa is a mammoth task and is the result of many years of study and research.

The resulting product is presented in four parts. Part 1: General Survey provides an introduction to the study as well as an analysis of Canadian plant distribution, the factors affecting it and the resultant patterns that emerge, a life form classification of vascular plants, and a description of floral regions in Canada. A brief list of nomenclatural changes resulting from the study is presented, followed by a list of abbreviations and the herbarium acronyms utilized in the text, a tabular conspectus of the flora, a glossary, and finally, the literature cited. Parts 2, 3, and 4 provide the systematic treatments. These are divided into Pteridophyta to Monocotyledoneae, Dicotyledoneae (Saururaceae to Violaceae) and Dicotyledoneae (Loasaceae to Compositae), respectively. Part 4 concludes with an index to the complete work.

The four hardbound books constitute a handsome set of volumes. The printing quality is excellent, with clear, well-arranged copy being presented on good-quality, firm, paper stock. Bindings are sturdy yet flexible, facilitating easy use of the books and ensuring durability. Although type size is necessarily small for economy's sake, readability has not been lost. Different type styles have been skillfully used with a minimum of negative space to provide a simple, clearly delivered text to enhance readability further. The index in Part 4 is printed on differently colored paper. This is a small thing, but helps the user of these volumes considerably. The absence of indices for each volume, necessitating constant reference to Part 4, is the only negative criticism I would raise in this regard. Overall, the physical preparation and presentation of the work are excellent.

Part 1: General Survey includes an interesting and informative, if somewhat dated, discussion of plant distributions in Canada and the factors affecting them. It seems to me, however, that the sections dealing with floral distribution formulae, and families and genera of restricted distribution, tend to be overly complex and academic in their application. In the same vein, I question the utility of defining distribution patterns so finely . . . to the point of delimiting a distinct geographical pattern on the basis of two species of *Isopyrum*, one each in southern Ontario and western British Columbia.

The discussion of floral regions of Canada is very complete, perhaps overly so. I wonder if so many species must be listed to describe characteristic floral elements for each region? The addition of common names, however, is appreciated. I found the anecdotal tangents (such as a discussion of fall colors in the Great Lakes — St. Lawrence Forest Region) to be interesting but out of context here. This is particularly true for the 'eco-tours' described in discussion of the western forest region. These somewhat rambling divergences become rather confusing and irritating. A map illustrating these floral regions would have added to this section.

The glossary is excellent. The author defines a much wider range of terms than one normally expects to find in floral manuals and does so in clear, concise language. I would add similar applause for the Literature Cited section, were it more complete. For some reason, many literature references are cited only in the species' accounts (e.g. *Alyssum desertorum, Arabidopsis saluginea*).

Parts 2, 3, and 4 are structured in a clear and obviously well-thought-out manner. A technical description introduces each family, followed by a key to the species therein. Genera are then listed alphabetically (a very useful feature), with references to pertinent literature accompanying each. Individual species' accounts follow the generic keys and are also placed in alphabetical order. Specific treatments start with the distribution formulae described in Part 1: General Survey, followed by a symbol representing their life form classification. I suspect that these will be largely overlooked by the reader, because of their complexity. These are followed by a very general but adequate habitat description. The account is concluded with a verbal description of the Canadian and North American range of each species, a listing of published distribution maps and of synonymy, largely as that synonymy relates to previously published Canadian literature. The distribution map feature is an excellent one that is too often overlooked in such manuals. The synonymy cited seems to be quite thorough. Range data, however, are quite inadequate. The method devised for describing these is cumbersome and misleading, especially for northern taxa. Describing the northern limit for such species as *Streptopus amplexifolius* and *Ranunculus macounii* is far less useful than defining their southern limits

(which is not done) and results in a serious loss in understanding. Some range statements (e.g. *Smilax herbacea* ". . . *north to Thunder Bay* [*Ontario*] . . .") are far too sweeping and lead to further confusion. The author seems to have relied very heavily on published range descriptions, without conducting a very critical evaluation of these (e.g. *Dryopteris simulata* (= *Thelypteris simulata*) is cited in Ontario on the basis of a literature citation; the voucher at DAO was revised to *T. palustris* years ago).

Subspecific taxa, including microspecies, subspecies, varieties, and forms, are keyed out within species' accounts and are discussed in the same manner as full species.

The author describes his taxonomic treatment of the flora of Canada as representing " . . . a relatively conservative species concept . . .". I found this difficult to evaluate, as the treatment varies from group to group. Ferns, for example are very conservatively treated (e.g. *Dryopteris cristata* var. *clintoniana* rather than *D. clintoniana*) whereas sedges are both 'split' (*Carex cumulata, C. merritt-fernaldii, C. brevior*) and 'lumped' (*C. laxiflora* s.l.)

A number of inconsistencies run through the text. Species which seem to be accepted as validly represented in the flora (e.g. *Ulmus pumila, Potamogeton capillaceus* (= *P. bicupulatus*)) are discussed within the accounts of other species and are not included in the keys. The reason for this confusion is not clear. Lists of hybrids for *Carex* and *Salix* are placed after the general account, but not so for *Quercus* or *Dryopteris*. (Indeed, the many hybrids of *Dryopteris* are not even discussed.) Some taxa which are discussed separately and are considered to be synonymous with other accepted species are not listed under the synonymy for that species (e.g. *Polygonum persicaria*, including *P. puritanorum*). Relatively small but annoying errors are duplicated repeatedly through the text (e.g. Algonquin Park, Ontario, is in Nipissing District, Ontario, not Renfrew County), suggesting that proofing was not as exacting as it could have been.

The most serious criticism I have of the work is the degree to which its content is dated. Although the author states that research was ended in mid-1972, one is hard pressed to find many post-1969 references. As a result, nomenclature and taxonomy are not significantly more up-to-date than that of *Gray's Manual of Botany* or *Britton and Brown's Illustrated Flora*. Important literature for such groups as *Draba* and *Woodsia*, available before and/or during 1972, was not used. This is particularly critical for such a difficult genus as *Draba* and leaves the present treatment virtually unworkable. Recent studies of this latter group recognized 40 species, in contrast to the 27 recognized in this work. Only 5 of the 7 species of *Spiranthes* and 13 of the 15 species of *Cirsium*, for example, are discussed here. Important literature dealing with the grasses of Ontario, the rare plants of various provinces, the thistles of Canada . . . and so on . . . also could not be incorporated.

The age of these data probably is also responsible for many range discrepancies (e.g. the northern limits of many southern species in Ontario seem to be 100 km or more south of their known extremes).

One could reasonably expect that this long-awaited manual would be a 'state-of-the-art' study . . . a confident, standard reference which the Canadian botanical community could refer to as their 'bible.' This work has some excellent features — such as a generally superior layout and physical construction, the reference to published range maps, a fine glossary — but these successes are severely compromized by outdated data, vague range descriptions, and a number of serious inconsistencies.

I must conclude that those considering its acquisition would be better advised to invest the few additional dollars required to obtain *Britton and Brown's Illustrated Flora*, or perhaps save some money by purchasing Boivin's *Enumeration des Plantes du Canada* and *Gray's Manual of Botany*.

This *Flora of Canada* is, unfortunately, *not* the 'bible' that has been eagerly awaited . . . more for that which is not included than for that which is.

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Multivariate Analysis in Vegetation Research

By Laszlo Orloci. 1978. Junk, The Hague (North American distributor: Kluwer, Boston.), 2nd edition, ix + 451 pp., illus. U.S. $49.00.

This book should be useful to advanced naturalists interested in mathematical derivations and calculations of complex statistical analyses involving large data sets. The book is unique because it bridges the gap between advanced plant ecology and complex statistical analyses. It explains the many different techniques used to classify the importance of a plant species in its community using easily collected data from a few small sampling sites. Most of the tech-

niques could easily be used by the animal ecologist. The book is written in the style of a long discussion or lecture, and it treats almost all known multivariate analysis methods.

Orloci describes multivariate methods that are extremely time-consuming to compute by examples with tiny data sets making the calculations simpler and easier to follow. He also provides listings of 27 BASIC computer programs with sample runs which handle many of the calculations described. These programs should be easily used by those with some computer training and their results easily interpreted by those with some statistical background.

In many areas the text becomes highly mathematical with little obvious connection to vegetative phenomena. For those naturalists without advanced mathematical training, these sections will be difficult to read.

Typographical errors are numerous. Even though a good author index appears, the subject index and glossary have poor coverage limiting the usefulness of the book as a quick reference. No list of tables and figures with pagination is given but tables and figures are cited in the text without page numbers. This becomes a problem because tables and figures are often many pages removed from the discussion concerning them and are thus difficult to find.

This 2nd edition is not much different from the first; a few (7) programs, new references, and some statistical methods are added. The "List of Symbols" has been dropped which, in my opinion, should not have been done.

Perhaps the best way to use this book is to read it in its entirety while taking notes for future reference. In this spirit, I strongly recommend this book for use by serious naturalists.

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Vascular Plants of Continental Northwest Territories, Canada

By A. E. Porsild and W. J. Cody. 1980. National Museum of Natural Sciences, Ottawa. viii + 667 pp., illus. $80.00.

This monumental work fills a significant gap in bringing together keys and descriptions of all the species of ferns and flowering plants of the mainland portion of the Northwest Territories. It represents many years of work and it is exciting to at last have it available. Gone are the days of tramping the southern Northwest Territories with backpacks full of provincial and Alaskan floras. It is sad that Dr. Porsild passed away before the book was published: his contributions will not be forgotten by northern botanists and students of natural history, for his books are the basic references on vascular plants.

In addition to their roles as Chief Botanist in Canada's National Herbarium (A. E. Porsild) and Curator of Canada's Department of Agriculture Vascular Plant Herbarium (W. J. Cody), both authors have had extensive field experience in the Northwest Territories. Dr. Porsild especially was no "summer botanist": he knew the north in all seasons and the value of plants to native peoples and to wildlife. The descriptions include numerous extra details from mosquito pollination of the northern bog-orchid to the parts of plants which are important to northern herbivores such as Caribou, Muskoxen, and ptarmigan.

The flora covers the 1112 known species plus additional species which are expected to occur here. There are line drawings for almost all species and distribution maps for all the native species. The drawings and distribution maps are conveniently located together and immediately following the descriptions of the species of each family. The distribution maps also indicate the extent of a plant's range in the rest of Canada, in Iceland, Greenland, Alaska, and the western tip of the USSR.

There is a nine-page section that documents botanical collectors who contributed specimens through 1976, the last date for inclusion of most distribution information. The collections are by no means exhaustive. It remains to be seen if the ranges of over one third of the species are as restricted as Cody suggests in *Vascular Plants of Restricted Range in the Continental Northwest Territories, Canada*, another National Museum publication. It is hoped that this excellent new flora will stimulate dozens of new distribution records! A more thorough knowledge of the Northwest Territories flora would assist in assessing which of the species with apparently restricted distributions are potentially rare or endangered.

The book is clearly a scientific, academically oriented publication and an essential acquisition for botanical and science libraries, and it will be of interest to many northerners and visitors to the north. Unfortunately, its high price will discourage many potential purchasers, especially among nonbotanists who want to take a book of this type with them for field identifications. (No. There are no color photo-

graphs!) It is unlikely that it will foster northern sciences as much as the authors might have intended: at this price it isn't likely to be readily available to northerners in local settlement schools and libraries.

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The Arctic and Antarctic: their division into geobotanical areas

By V. D. Alexsandrova. 1977. Nauka, Leningrad. English Translation by Doris Löve. 1980. Cambridge University Press, New York. 247 pp. illus. U.S. $34.50

Plant taxonomists and ecologists who are interested in circumpolar ecosystems and who have a limited facility with the Russian language will be pleased when they learn that V. D. Aleksandrova's 1977 book has been translated into English. The translation has been made by Doris Löve who is well known for her work on circumpolar plant taxonomy–geography subjects and who is therefore admirably suited to provide this translation.

The book brings Aleksandrova's personal experience, from a career that spans at least 40 years (her earliest cited publication is 1937), together with the circumpolar literature. Well over 500 references are used and, of these over 300 are in the Russian language. About 30% of the references predate 1949, while 10, 30, and 30% of the references were produced in the 1950s, 1960s, and 1970s, respectively. The book consists of two short chapters on geobotanical regions of the Arctic (Chapter 1, 18 pages) and Antarctic (Chapter 4, 18 pages) plus two chapters that describe the arctic tundra (Chapter 2, 125 pages) and arctic polar deserts (Chapter 3, 25 pages) in greater detail. Alexsandrova divides the Arctic and Antarctic into hierarchal classification of regions, subregions, provinces, subprovinces, and districts. Although the subject is described as geobotanical, the work is primarily a description of plant species distrubution. There is very little quantitative information on plant community composition, on plant succession or community response to disturbance, on soils and geology, or on climatic regimes.

This book is a very subjective approach to the division of vegetation into units and it is therefore important to understand the philosophy of the writer. I would suggest that the reader begin with Löve's Foreword and then proceed through the Preface and Conclusions (Chapter 5), before beginning to abosrb the detailed species information in Chapters 1 through 4. Readers who are not familar with the European and Russian plant community terminology may find some initial difficulty; however, these terms present few problems in understanding the work. As very small-scale maps are provided in the text, I found it useful to have a somewhat larger-scale map of the circumpolar region in front of me as I read. Many small geobotanical divisions could have been effectively presented in photographs or topographical soil–vegetation profiles.

This work will be very satisfactory to plant taxonomists who are interested in species distribution in the circumpolar area. It will be of limited value, however, to plant ecologists who are interested in plant ecophysiology or quantitative plant synecology. The book serves as a useful introduction to the Arctic of the Old World and the Antarctic for students who are initiating studies in polar plant ecology or who may be preparing for visits to these areas.

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Flore des champignons au Québec et régions limitrophes

By René Pomerleau. 1980. Les Éditions la Presse, Montréal. 652 pp., illus. $65.

Congratulations to Dr. Pomerleau, who, with the publication of this tome, has given us the most comprehensive text on the mushrooms (a term used here to include all fungi over about 0.5 cm in size) not only of Canada but of North America. As the author admits, the flora is not complete, descriptions of all the mushrooms of Quebec are not included, but nearly 1400 of the larger species are treated with many more mentioned in the comparative notes. No one in any other book has treated such a diverse and large number of the North American fungi.

The book is well illustrated with 305 species pictured in color. Unfortunately some plates are tinted an unnatural pink. Line drawings show the shape, the principal gross features, and some microscopic features of 809 species.

The book is divided into two principal sections. The general part of 165 pages lucidly introduces the reader to the mushrooms. In the chapter on the mushrooms in the history of man, we are told that the first written report of intoxication caused by mushrooms appeared more than 400 years before Christ. Further that "mushroom" is derived from "mousseron," the common name in Normandy for the *Tricholoma* of St. George. The role of mushrooms in the origins of several religions is discussed. Other sections outline their biology, illustrate and define their characters, and formulate the systematics section of the book. Their ecology and uses by man, especially their edibility or inedibility, are the subjects of other chapters. The general section is directed at the beginning students, who may be confused when they see, as in Plate 1, both microscopic and macroscopic features with no scale to indicate that haustoria are considerably smaller than even small mushrooms.

The descriptive part of the book is divided into chapters each treating similar or allied groups of fungi. The final sections of the book are a glossary, seven pages of bibliographic citations and indices of the French, English, and Latin names. The book is large, 28.5 × 22 cm, and heavy, 2.8 kg, but the binding does not appear to be strong enough to survive even moderate use.

The order of arrangement of the genera, i.e., the systematics, follows the most modern schemes in most cases. In the family Polyporaceae (the wood rot fungi), however, a number of generic names last used in 1928 have been unexplainably resurrected.

This book will be the authoritative work on the mushrooms for many years, not only of Quebec but northeastern North America. That this impressive flora, which was centered on the southermost region of Quebec, is now the most detailed flora for Canada emphasizes our ignorance of the mushroom flora of Canada. Without knowledge of the species we can hardly understand their varied role in nature, neither can we fully use their potential contribution to the fields of forestry, horticulture, and mycophagy.

This is a magnificent contribution. It will stimulate interest and research on all aspects of the ecology and biology of the mushrooms.

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ENVIRONMENT

Bibliography of the Natural History of Newfoundland and Labrador

By M. Laird. 1980. Academic Press, London. lxxxi + 376 pp. $57.50.

Professor Laird, in this most useful reference book, has brought together about 4000 published and a few unpublished references to the natural history of Newfoundland and Labrador. These, in many instances, are accompanied by a sentence or two outlining the significance of the publication.

This work, which was begun by the author in 1967 on his arrival at Memorial University, is the result of much searching of both European and North American literature. It is without question a labor-of-love. No such work is ever complete, but from the number of obscure references noted it is obvious that the author delved deeply and no doubt had much cooperation from other interested individuals. I was surprised, however, to find that there was no reference made to *Bibliography of Canadian Plant Geography* by Adams and Senn which appeared in *Transactions of the Royal Canadian Institute* over the years 1930 to 1947 and was continued in Canada *Department of Agriculture Publication* 863 (1951). I have noted a number of references in this series to occurrences of plant species in Newfoundland and Labrador not found in the present work.

That Professor Laird is well versed in the natural history, both past and present, of his area is well brought out in over 50 introductory pages in which he touches on many early references to visits by well-known naturalists such as Banks and Audubon as well as less tangible hearsay mentions such as "A monster of the sea." Here too, he expresses concern regarding the enormous increase in exploitation of the Grand Banks since World War II as well as the implications of importations of non-native species to the island and unforeseeable consequences related thereto.

The work is made more useful by the inclusion of an index. It will be a welcome tool for anyone beginning a study on some phase of the natural history of Newfoundland and Labrador.

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Terrestrial Environments

By J.L. Cloudsley-Thompson. 1979. Halsted Press (Wiley), New York. 253 pp. U.S. $14.95

Cloudsley-Thompson attempts to write about the "more important terrestrial habitats of the earth, with special respect to their influence on the fauna." He has "tried to illustrate the selective influence of the environment on its fauna and, conversely, the influence of animals on their habitat." Essentially the book is an introduction to global terrestrial ecology.

Terrestrial Environments has 15 chapters. The first chapter is an introduction of zoogeography, a preamble on the theories of continent formation and basic evolution. Environmental factors, specifically climate and soil, are reviewed in the second chapter. In chapters 3–10 the important terrestrial habitats: tropical forest, savannah, desert, steppe, temperate forest, taiga, tundra and snowlands, and mountains are discussed.

Cloudsley-Thompson briefly reviewed the climate and vegetation of each habitat, but devoted most of the text to the faunal component. For some reason he did not review the soil for each habitat, one of the important environmental factors outlined in Chapter 2.

The book is full of rambling, ambiguous terms that serve only to confuse the reader. The outstanding problem lies with the author's use of nomenclature. Common names used to describe plant and animal species differ throughout the world. For example, the common name for the Moose in Europe is Elk. The European Elk and the North American Moose are given the same Latin binomial (*Alces alces*) because they are the same species, which is different from the North American Elk (*Cervus elaphus*). Cloudsley-Thompson did not discuss this difference in his book. To confuse the reader further, he incorrectly listed some subspecies of North American Moose, ". . . (*Alces americana* and *A. gigas*)" (p. 132), without explanation. In North America there are four recognized subspecies of Moose (*A. alces*): *A. a. americana, A. a andersoni, A. a. gigas,* and *A. a. shirasi* (Peterson 1955).

The author banters about terms such as "forest reindeer," "tundra deer," "caribou," "domesticated reindeer," "wild reindeer," and "deer" without at least briefly discussing the common name differences (e.g., the North American Caribou is the European and Asian Reindeer equivalent) and the Latin binomials. In the context of the author's discussion, all of the above named animals belong to the species *Rangifer tarandus*; however, there are many subspecies. Cloudsley-Thompson states that "forest reindeer (*Rangifer tarindus*) (sic) are larger than tundra deer." This is most confusing to the novice reader. In Canada the "forest reindeer" or Woodland Caribou is *R. t. caribou* and the "tundra deer" or Barren-ground Caribou is *R. t. arcticus*.

The problem could have been alleviated if Cloudsley-Thompson had identified the global variation among common names, followed the correct procedure for the use of Latin binomials, and used the most accepted common name(s) in conjunction with the Latin binomial.

The book is plagued with many incorrect statements. For example, on page 135 it is stated that "Tundra, a word of Finnish origin, meaning an open forestless stretch of country, is applied to a high tract of land north of the Arctic Circle." The Arctic Circle lies well north of 65° N, but the tundra in the eastern Canadian Arctic extends south of 60° N.

On page 138 the author wrote that "mammals of the tundra have no special protection against the winter." This statement is incorrect. Shvarts (1963, cited by Pruitt 1978) concluded the storage of energy reserves to be a most important adaptation of northern mammals. He also noted that species best adapted to tundra conditions evolved the ability to maintain a normal biological function with a lowered metabolism.

In the chapter entitled "Tundra and Snowlands," it is stated that "during the winter, the gound is covered with a deep layer of snow." It is true that snow reaches considerable depth over certain portions of the Russian tundra (Formozov 1964), but there are areas where only small amounts of snow fall (e.g., on the coast, near the Yana River, USSR). In Canada, precipitation decreases northward; the continental tundra and the High Arctic Islands are virtual deserts.

On page 148 the author stated that "carnivorous animals nevertheless fare miserably in the Arctic winter and drag out a bare existence. Bears, wolves, and foxes suffer extremeties of famine; they become very emaciated and their stomachs empty for long periods." I don't doubt that there are instances of starvation; however, it is not as common as the author leads the reader to believe.

Cloudsley-Thompson made some statements that leave the reader hanging. On page 130 he stated, in reference to montane and subalpine forest, that "this type of northern coniferous forest is due in part to local physiographic factors and, again, differs from the true taiga." The author does not tell the reader how it differs from the taiga.

The remaining chapters deal with: microenvironments, fresh waters, the selective influence of the organism on its habitat, and ecological regulation. I fail to see the purpose behind devoting a chapter to limnology when the book is supposed to dwell on terrestrial habitats.

There are two appendices; they are lists of world climates and vegetation, and the deserts of the world. In addition, there is a bibliography, an index to the authors cited in the text, and a general subject index. There are ink drawings, tables, and maps throughout.

I recommend this book only to those willing to sort out the annoying errors throughout the text.

Literature Cited

Formozov, A. N. 1964. Snow cover as an integral factor of the environment and its importance in the ecology of mammals and birds. Boreal Institute, University of Alberta, Occasional Paper Number 1. 176 pp.

Peterson, R. L. 1955. North American Moose. University of Toronto Press. 280 pp.

Pruitt, W. O. Jr. 1978. Boreal ecology. Edward Arnold (Publishers) Limited, London. 73 pp.

Shvarts, S. S. 1963. Adaptation of terrestrial vertebrates to sub-arctic conditions. Academy of Science USSR, Ural Branch, Institute of Biology. Trudy 33. 132 pp. (cited by Pruitt 1978.)

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Biogeography

By E. C. Pielou. 1979. Wiley, Toronto. ix + 351 pp., illus. U.S. $22.50.

This book should be useful to those wanting an overview of earth's evolutionary history based upon past and present distributions of plants and animals. Most aspects of biogeography are discussed, but plants are dealt with more often than fishes, amphibians, or reptiles. The author, taxonomic, and subject indexes make the text a useful reference.

The book reads more easily than expected for the subject matter concerned. Continental drift, ice ages, dispersal, migration, disjunctions, and biogeographic realms, phylogenies, and genetics, and marine, island, and ecological biogeography are heavily dealt with in their own chapters or sections. The subject is properly introduced in early chapters, and later chapters concern advanced study. The chapter on phylogeny and geographic spread (Chapter 3) is perhaps the best in the book and should be read by all persons even vaguely interested in biogeography. More time is spent on Canadian biogeography than in other biogeography texts.

Some sections require somewhat complex mathematical ability, but the author has intentionally arranged these sections so they are easily skipped without loss of continuity. Even though some of the mathematical functions are difficult to follow, several of those dealt with should be used in the near future by biogeographical researchers.

Typographical errors are numerous. Many references are cited in the text but are absent from the bibliography. Most figures are difficult to interpret because few labels appear to aid in orientation. Although the Geological Time Scale is located in a useful place (the end papers), it is hard to understand as diagramed.

Other items of interest throughout the text include the following: the percentage of plants with non-lobed leaves is associated with mean annual temperature (p. 45). Plants evolve slower and have larger geographic ranges than mammals (p. 49–50). Plants (50 species in 21 families) with branches emerging at right angles to the main stem are found only in New Zealand (p. 214). Evidence suggests that congeneric species are most often found with sympatric ranges (Chapter 7).

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The Mystery of Migration

Edited by Robin Baker. 1980. Wiley, Toronto. 256 pp., illus. $29.95.

Migration has puzzled and fascinated man for centuries. Anyone aware of the natural world cannot help but be struck by the migratory phenomenon. An introductory student in migration will find some stunning individual feats: the circumpolar, annual flight of an Arctic Tern; the transcontinental journey of a Monarch Butterfly; the reverse-salmon cycle of the European and North American eel; and much more.

The other particularly evident fact about migration is that it is practised, in one form or another, by nearly every living organism. *The Mystery of Migration* makes a point of defining migration in its broadest terms: "migration — movement from one place to another." Such a definition opens a new world of migrants: plants seeds, snails on a beach, plankton in

the ocean, Moose moving up or down a mountainside, and of course, Man. *Homo sapiens* is seen as a remarkable migrant having colonized the world from his beginnings about 3 000 000 years ago in the grasslands of Africa.

The book applies this broad definition to all life forms from plants through invertebrates, insects, fish, amphibians, and reptiles, birds, bats, aquatic animals, land mammals, to man. A comprehensive theory of migration and some interesting comparisons are developed. The studies of "lifetime tracks" (the path traced out in space by an individual between birth and death) is especially interesting.

Dr. Baker has pulled together a very professional group of contributors. The writing throughout is clear and concise and will accommodate either a casual glance at the text under illustrations, or a more careful study of the complete text. The book is lavishly illustrated with color and black and white photographs. Excellent additions to the illustrations are the maps, charts, and graphs which have been produced for the book. Some of the graphs convey a great deal of information in a very concise way.

Not only is there a good index, essential to such a book, but there are also subjects printed on the top-right corner of every page. This superb indexing will make the book very accessible to the student-in-a-hurry. The contributors are all English, and thus there is an emphasis on 'old-world' creatures. This emphasis is well placed, however, because most of the pioneering work in migration was done in Europe and especially the United Kingdom.

The Mystery of Migration is an excellent book both for the inquisitive browser and for the more serious student of migration. While a comprehensive look at a spectacular natural phenomenon is provided, it seems fitting that part of the mystery still remains. We have more to learn from the salmon, the marine turtles, the terns, the whales, and the worms.

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Biology of Communication

By D. Brian Lewis and D. Michael Gower. 1980. Tertiary Level Biology Series, Halsted Press, John Wiley and Sons, Toronto and New York. 239 pp., illus. U.S. $27.95.

The title *Biology of Communication* evokes scenes of fledglings eliciting food from their parents, and of insects sending messages to other insects via pheromones. While these events are considered in this book, the subject matter probes far more deeply, into neurophysiology and the nature of the media through which signals travel and which necessarily affect the signals and their reception. Indeed the final chapter, dealing with methods of analyzing sequences of behavior by matrices, information analysis, and multivariate analysis, will be of interest only to researchers. The authors say that the previous knowledge assumed before one reads this work is a basic understanding of physiology and of the principal concepts in behavior. Even so, one wonders if the presentation need be as erudite as it is. An early section begins "In the visual modality, animals have the capacity for coding intensity, temporal patterning, frequency (colour) and spatial patterning (by line coding) to a sophisticated level." For this introduction would it not be simpler to write that animals can see well, and are able to judge an object's relative intensity, motion, color, and shape?

A general impression one receives from this book is how much is known about communication, especially in insects which lend themselves to physiological experiments, and in birds which have rather stereotyped and discrete behavior patterns. On further reflection, however, when one remembers that there are perhaps one million species of animals in all, one is awed at the infinite amounts of knowledge which must yet be undiscovered. In any case the intricacies of communication reported here are amazing. In discussing mimicry, the authors explain that an edible insect mimicking in color an evil-tasting one cannot become too abundant relative to the model, because the first sampling of a predator is likely to shape its future responses. One insect mimic therefore emerges later in the season than its model to help solve this problem. As another example, the female cabbage looper moth has learned to disperse her male-attracting scent in relation to the wind velocity, so little is wasted. At low wind speeds she exposes her pheromone-producing glandular surfaces for about 20 min, with the exposure time decreasing to 5 min at wind speeds of 3 m per second.

Much of the information discussed is illustrated in figures which vary greatly in elaborateness. Some express simple ideas in straight-forward fashion while others, taken from primary sources, are almost incomprehensible to the average reader. The subject matter ranges equally widely, from how flowers communicate to insects, to the functioning of a nerve cell,

to the properties of water, to examples of courtship in butterflies and vertebrates.

A casual naturalist will probably think this book too academic, but professional ethologists will find much in it to interest them. They will be able to ponder statements querying some of the work of Tinbergen and Lorenz, and assess claims such as that "Hybrids almost always show reduced 'fitness' in some respect." They will also enjoy browsing through the nearly 300 references, almost all from the past three decades.

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Environmental Effects of Dams and Impoundments in Canada: experience and prospects

By R. M. Baxter and P. Glaude. 1980. Canadian Bulletin of Fisheries and Aquatic Sciences 205. Supply and Services Canada, Hull. 34 pp. $2.50 in Canada; $3.00 elsewhere.

This Canadian government bulletin is an extensive review of the literature in a rapidly developing area. Using a previous review (Baxter, R. M. 1977, Environmental Effects of Dams and Impoundments. Annual Review of Ecology and Systematics 8: 255-283) as a basis, the authors have included more recent studies and have presented the subject in a Canadian context. It is written in a comfortable style and is very well edited; this reviewer found only one error in the text.

For a general readership interested in learning something about the environmental issues involved in dam projects, this publication will provide a valuable introduction. It covers a wide range of potential problems and benefits, citing Canadian examples whereever possible. The caveat urging caution in applying foreign experience to northern Canadian environments is well-founded. The table of contents, unusual in such a short work, provides a quick guide to specific topics.

This communication will also be a useful guide to the literature for the student, scientist, or engineer who intends to study dam-related problems in depth. It contains 243 references and, fortunately, uses the author and date-alphabetized citation system rather than the sequentially numbered reference format used in many reviews.

While this bulletin succeeds admirably in considering most conceivable impacts, I was mildly disappointed by the section on climatic effects. The authors recognize the effect of water bodies on evaporation and heat budgets, but do not mention the potential additivity of this effect. Because the total number of reservoirs can only be expected to increase, the total surface area covered by water must also increase. It is therefore possible that impacts which seem only local when viewed individually may ultimately have regional or even global climatic consequences at some point in the future.

As with most literature reviews, this one will become outdated as more studies appear. As the authors note, the post impoundment studies on the James Bay project, when they are completed, will be a major influence on our thinking.

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MISCELLANEOUS

Morphometrics: the multivariate analysis of biological data

By Richard A. Pimentel. 1979. Kendall/Hunt, Dubuque, Iowa. x + 276 pp., illus. U.S. $19.95.

This book is a complete introduction to meaningful analysis of large data sets from studies in field biology. It is a useful guide for field biologists interested in using multivariate biometry without having to consider the in-depth, mathematical terminology used by most multivariate texts. Mathematical proof of explained methodology appears as an afterthought instead of the primary focus it receives in most texts that propose biological orientation. This fact makes this text the only one of its kind written by and for a field biologist. It could serve as a text in a biometry course subsequent to that by R. R. Sokal and F. J. Rohlf (1969, *Biometry: the principles and practice of statistics in biological research*).

Elementary matrix algebra is explained in such a way that anyone with algebraic training can under-

stand. The shortcomings of multiple correlation and regression are discussed. Multivariate analysis of variance and covariance, principal component, factor, canonical correlation, ordination, cluster, and discriminant analyses are explained in their respective chapters. In short, these subjects provide the field researcher with the most up-to-date statistical tools known to us for explaining biological observations.

Perhaps most important from the viewpoint of a researcher wanting to learn about multivariate biometry is the 23-page glossary. There are more than 450 terms listed with definitions written in plain, comprehensible English.

Typographical errors are moderate and some pages seem to have whole sentences missing (eg. pp. 25, 197). Perhaps the major problem with this book is that a single data base on Painted Turtles is analyzed and reanalyzed by various methods throughout the text which limits the variety of real world examples shown. Overall, I strongly recommend this text for use by field biologists.

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Shadow of the Hunter — stories of Eskimo life

By Richard K. Nelson. Illustrated by Simon Koonook. 1980. The University of Chicago Press, Chicago, Illinois. xiii + 282 pp. U.S. $12.50.

"The Eskimos who live in widely scattered settlements along the Arctic Coast and north Slope of Alaska call themselves Inupiat, which means 'the real people.' In this way they set themselves apart from, and above, the rest of humanity. Perhaps, considering the harshness of the environment in which they live, they are entitled to this distinction. I hope the chapters that follow will give you some basis to judge for yourself."

With these words Richard Nelson begins to weave a tale of a year in the lives of the Tareogmuit (sea-oriented Eskimos) of the fictional village of Ulurunuk. We are taken from *Siqinyasaq Tatqiq* — moon of the returning sun (January), through *Irniivik Tatqiq* — the moon when animals give birth (June), to *Siqinrilyaq Tatqiq* — the moon with no sun (December). While on our fascinating journey we experience the cold loneliness of winter seal hunting; the excitement of spring whaling; and the danger and adventure of hunting Walrus and Polar Bear during the times before snow machines, outboard motors, down clothing, soda pop, and television. Nelson provides us with considerable insight into the monumental everyday logistical effort required of the women, children, and men to support the more "exciting" activities. He exposes us to the social interrelationships, competition, fear, and pride among the people of Ulurunuk. *Shadow of the Hunter* is basically a collection of 10 short stories, each one corresponding to a "moon" in the Tareogmuit year. The stories are factual and exciting. Nelson's style is relaxed and readable. He is an astute observer and is able to convey detail in an interesting manner. Individually, each story can stand on its own merits, but the stories are linked by the changeable environment near Ulurunuk. The book is relatively free of typographical errors and the type is attractive. The drawings by Simon Koonook, a Point Hope Eskimo and student at the University of Alaska, greatly enhance the book. Both Richard Nelson and The University of Chicago Press should be commended for their inclusion. I hope that we will see more of Simon Koonook's art in the future. One shortcoming which I felt the book had, although briefly touched upon in the *Appendix*, was the lack of a comparison between Eskimo life as depicted in this book and present life in the coastal villages of Alaska. I am afraid that some people will assume that this book portrays life as it is today. It does not.

As with other books about Eskimos (Brower, Freuchen, Stefansson, and others), and based upon my own experiences in the coastal villages of northern Alaska, it is always amazing how attuned to their environment are the Tareogmuit. They are able to predict changes in weather or sea-ice conditions and are reacting to these changes before most *Tanik* (non natives) realize that a change is underway. The feelings and insights portrayed in this book could only be presented by a person who has experienced what is written.

Nelson spent 14 months in the village of Wainwright on the northwest coast of Alaska studying "Eskimo methods of hunting, traveling and surviving on the sea ice." This Air Force funded project was designed to gather information for survival manuals and it produced Nelson's first book *Hunters of the Northern Ice* (The University of Chicago Press, 1969). Although ethnographic by nature, *Shadow of the Hunter* continues where *Hunters of the Northern Ice* leaves off by reminding us that we are dealing with living people and a living culture, people who have hopes, desires, and frustrations like the rest of us.

Researchers who have written for the general public have generally been suspected by the scientific community of being charlatans or at least not sufficiently serious about science. In addition, scientific publications are, as a rule, not interesting reading to a layperson. Consequently most of us fail to find out about some very interesting research and why we are supporting it with our tax dollars. Fortunately in recent years several top-level researchers have come forward to explain or present their research findings in a readable form. To this list of scientist-writers we must add Richard K. Nelson, who is a naturalist of the highest order as well as an interesting and informative writer.

In addition to *Shadow of the Hunter* and *Hunters of the Northern Ice*, Nelson has written *Hunters of the Northern Forest*. This latter was his second book and doctoral dissertation. It is a human ecological study of the Athapaskan speaking Kutchin Indians of east-central Alaska. I encourage you to read *Shadow of the Hunter* and Nelson's other works, as they will provide you with many hours of enjoyment and entertainment.

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NEW TITLES

Zoology

Advances in the study of behavior, Volume II. 1980. Edited by J. S. Rosenblatt, R. A. Hinde, C. Beer, and M.-C. Busnel. Academic Press, New York. 392 pp. U.S. $35.

Arctic animal ecology. 1980. By Hermann Remmert. Translated from German by J. Wieser. Springer-Verlag, New York. 280 pp., illus. U.S. $24.80.

Atlas of benthic shelf Foraminifera of the southwest Atlantic. 1980. Edited by E. Boltovskoy, G. Giussani, S. Watanabe, and R. Wright. Junk, The Hague. vi + 148 pp., illus. U.S. $57.90.

The birdwatcher's A–Z. 1980. By Alan J. Richards. David and Charles (Canadian distributor McGraw-Hill Ryerson, Toronto). 336 pp., illus. £12.50.

British coastal shrimps and prawns: keys and notes for the identification of the species. 1979. By G. Smaldon. Academic Press, New York. vi + 126 pp., illus. U.S. $11.50.

†**The Canada Goose (*Branta canadensis*): an annotated bibliography.** 1981. Compiled by Scott R. Craven. Special Scientific Report — Wildlife No. 231. United States Department of the Interior, Washington. 66 pp. Free.

The desert bighorn: its life history, ecology, and management. 1980. Edited by Gale Monson and Lowell Sumner. University of Arizona Press, Tucson. 370 pp. Cloth U.S. $27.50; paper U.S. $14.95.

Dossier Caribou: écologie et exploitation du Caribou du Québec–Labrador. 1979. Edité par François Turdel et Jean Huot. Recherches Amérindiennes au Québec, Montréal. 166 pp., illus. $7.50.

Easy identification guide to North American snakes. 1979. By Hilda Simon. Dodd, Mead, New York. 128 pp., illus. U.S. $8.95.

Entomology. 1980. By Cedric Gillott. Plenum, New York. 675 pp., illus. U.S. $49.50 ($59.50 in Canada); text edition U.S. $22.50.

Evolution of the vertebrates. 1980. By Edwin H. Colbert. 3rd edition. Wiley, New York. 510 pp. U.S. $25.

***A field guide to the birds east of the Rockies.** 1980. By Roger Tory Peterson. 4th edition. Houghton, Mifflin (Canadian distributor Thomas Allen, Markham, Ontario). 384 pp., illus. Cloth $19.50; paper $12.95.

***A guide to the birds of Alaska.** 1981. By Robert H. Armstrong and the editors of Alaska magazine. Alaska Northwest, Anchorage. 320 pp., illus. U.S. $18.95 plus U.S. $1 postage.

Insect photoperiodism. 1980. By Stanley D. Beck. 2nd edition. Academic Press, New York. 392 pp. U.S. $32.50.

Invertebrate animals: collection and preservation. 1980. Compiled by Roger J. Lincoln and J. Gordon Sheals. Cambridge University Press, New York. viii + 150 pp., illus. Cloth U.S. $22.50; paper U.S. $6.50.

The island waterfowl. 1980. By Milton W. Weller. Iowa State University Press, Ames. 144 pp., illus. U.S. $10.95.

***Manual of Nearctic Diptera. Volume 1.** 1980. Sponsored by Biosystematics Research Institute. Agriculture Canada, Ottawa. Monograph 27. 674 pp., illus. $40 in Canada; $48 elsewhere.

Merlins of the Welsh marches. 1980. by D. A. Orton. David and Charles (Canadian distributor McGraw-Hill Ryerson, Toronto). 160 pp., illus. £6.95.

***Migrant shorebird ecology with special reference to shorebird migration along the north-eastern shore of Lake Ontario.** 1980. By Peter William Strahlendorf. Napanee District, Ontario Ministry of Natural Resources, Napanee. 96 pp., illus. $5.

*__The mystery of migration.__ 1980. Edited by Robin Baker. Wiley, Toronto. 256 pp. $29.95.

†__Naked species of *Gondolella* (Conodontophorida): their distribution, taxonomy, and evolutionary significance.__ 1980. By Peter H. von Bitter and Glen K. Merrill. Life Sciences Contributions 125. Royal Ontario Museum, Toronto. 49 pp., illus. $3.

*__North American birds of prey.__ 1980. by William Marshall. Gage Publishing, Toronto. 1976 pp., illus. $29.95.

*__Les Oiseaux familiers du Québec.__ 1980. Par Julien Boisclair. Stanké, Montréal. 184 pp., illus. $24.95.

*__The Peregrine Falcon.__ 1980. by Derek Ratcliffe. Buteo Books, Vermillion, South Dakota. 416 pp., illus. U.S. $42.50.

†__Principles of fishery science.__ 1981. By W. Harry Everhart and William D. Youngs. 2nd edition. Cornell University Press, Ithaca. 349 pp., illus U.S. $16.50.

__The role of animals in biological cycling of forest–steppe ecosystems.__ 1980. By R. I. Zlotin and K. S. Kodashova. Translated by W. Lewus and W. E. Grant. Edited by N. R. French. Dowden, Hutchinson, and Ross (distributed by Academic Press, New York). 240 pp. U.S. $19.50.

__Rotatoria.__ 1980. Edited by H. J. Dumont and J. Green. Proceedings of a symposium. Hydrobiologia volume 73. Junk, The Hague. xii + 268 pp. U.S. $79.

*__Les salmonidés des eaux de la plaine de Montréal. 1. Historique, 1534–1977.__ 1980. Par Vianney Legendre, Jean-René Mongeau, Jean Leclerc, et Jocelyne Brisebois. Rapport Technique 06–27. Service de l'aménagement et de l'exploitation de la faune, Québec. 280 pp.

*__Les salmondés des eaux de la plaine de Montréal. 2. Biométrie, biogéographie, 1970–1975, et registre de pêches, 1941–1976.__ 1980. Par Vianney Legendre, Jean Leclerc, et Jocelyne Brisebois. Rapport Technique 06–28. Service de l'aménagement et de l'exploitation de la faune, Québec. 139 pp.

*__Small mammals.__ 1981. By Robert E. Wrigley. Canadian Album Series: a coloring adventure in Canadian themes. Hyperion Press, Winnipeg. 40 pp., illus. $4.95.

__Strictly for the chickens.__ 1980. By Frances Hamerstrom. Iowa State University Press, Ames. 136 pp., illus. U.S. $11.95.

__Time in animal behavior.__ 1980. By M. Richelle and H. Lejeune. Pergamon Press, Elmsford, New York. 282 pp., illus. Cloth U.S. $50.50; paper U.S. $24.20.

__Venomous snakes of the world: a checklist.__ 1980. By K. A. Harding and K. R. G. Welch. Pergamon Press, Elmsford, New York. 200 pp.

__Wildlife management techniques manual.__ 1980. Edited by S. D. Schemnitz. 4th edition. The Wildlife Society, Washington. 722 pp., illus. U.S. $20.

__Wolves, bears, and bighorns: wilderness observations and experiences of a professional outdoorsman.__ 1980. By John S. Crawford. Alaska Northwest, Edmonds, Washington. 192 pp., illus. Cloth U.S. $23.95; paper U.S. $15.50.

__Zoogeography and diversity of plankton.__ 1979. Edited by S. van der Spoel and A. C. Pierrot-Bults. Halsted (Wiley), New York. viii + 410 pp., illus. U.S. $69.95.

Botany

__Atlas of the flora of Pennsylvania.__ 1979. By Edgar T. Wherry, John M. Fogg, Jr., and Herbert A. Wahl. University of Pennsylvania Morris Arboretum, Philadelphia. xxx + 390 pp. U.S. $9.95.

*__The biology of the bromeliads.__ 1980. By David H. Benzing. Mad River Press, Eureka, California. xvi + 305 pp., illus. + plates. U.S. $14.40.

__Flora of the Bahamian archipelago.__ 1981. By D. S. Correll, J. Cramer, Braunschweig, Germany. c. 1300 pp., illus. c. U.S. $96.

__Flora of Baja California.__ 1980. By Ira L. Wiggins. Stanford University Press, Stanford, California. 1025 pp. U.S. $65.

*__Living with plants: a guide to practical botany.__ 1980. By Donna N. Schumann. Mad River Press, Eureka, California. xx + 325 pp., illus. U.S. $14.20.

__Plant classification.__ 1979. By Lyman Benson. 2nd edition. Heath, Lexington, Massachusetts. 901 pp., illus. $26.95.

†__Plants of Quetico and the Ontario Shield.__ 1980. by Shan Walshe. University of Toronto Press, Toronto. xvi + 152 pp., illus. Cloth $25; paper $7.95.

__And some brought flowers: plants in a new world.__ 1980. By Mary Alice Downie and Mary Hamilton. University of Toronto Press, Toronto. 160 pp., illus. $24.95.

*__The vegetation and phytogeography of coastal southwestern James Bay.__ 1980. By J. L. Riley and S. M. McKay. Life Sciences Contributions 124. Royal Ontario Museum, Toronto. 81 pp., illus. $5.50.

Environment

*__The Arctic and Antarctic: their division into geobotanical areas.__ 1980. By V. D. Alek Sandrova. Translated by Doris Love. Cambridge University Press, New York. xiii + 274 pp., illus. U.S. $34.50.

*__The boreal ecosystem.__ 1980. By James A. Larsen. Academic Press, New York. 500 pp., illus. U.S. $45.

*__The Canadian Environment: data book on energy and environmental problems.__ 1980. By Madelyn Webb. Saunders, Toronto. 166 pp., illus. $9.95.

__Cape Cod environmental atlas.__ 1979. Edited by Arthur H. Brownlow. Boston University Department of Geology, Boston. xvi + 62 pp. + plates. U.S. $5.

__Conservative biology: an evolutionary-ecological perspective.__ 1980. Edited by Michael E. Soule and Bruce A. Wilcox. Sinauer, Sunderland, Maine. xv + 395 pp., illus. U.S. $14.95.

*__Ecology and field biology.__ 1980. By Robert Leo Smith. 3rd edition. Harper and Row, New York. xii + 835 pp., illus. U.S. $18.95.

__Ecology: a textbook.__ 1980. By Hermann Remmert. Translated from German by M. Biederman-Thorson. Springer-Verlag, New York. 189 pp., illus. U.S. $21.30.

__Ecology of highlands.__ 1980. By M.S. Mani. Monographiae Biologica, 40. Junk, The Hague. xiv + 236 pp., illus. U.S. $58.

__Erosion and environment.__ 1980. By Milos Holy. Pergamon Press, Elmsford, New York. 266 pp., illus. U.S. $55.

__Euphrates and Tigris: Mesopotamian ecology and destiny.__ 1980. Edited by J. Rzoska. Monographiae Biologicae, 38. Junk, The Hague. x + 122 pp., illus. U.S. $31.50.

__Examination of water for pollution control: a handbook for managers and analysts.__ 1981. Edited by M.J. Suess. Pergamon Press, Elmsford, New York. 1700 pp., illus. U.S. $374.

__The global predicament: ecological perspectives on world order.__ 1979. Edited by David W. Orr and Marvin S. Soroos. University of North Carolina Press, Chapel Hill. xvi + 398 pp. U.S. $19.

__How to save the world: strategy for world conservation.__ 1980. By Robert Allen. Barnes and Nobles, Totowa, New Jersey. 150 pp., illus. U.S. $12.95.

__Hypertrophic ecosystems.__ 1980. Edited by L. Mur and J. Barica. Developments in Hydrobiology, 2. Junk, The Hague. 330 pp. U.S. $87.

__Island ecology.__ 1979. By M. L. Gorman. Chapman and Hall, London, 80 pp., illus. U.S. $4.95.

__Landscape ecology.__ 1979. Edited by P. Müller and C. Rathjens. Junk, The Hague. vi + 224 pp., illus. U.S. $52.65.

__Limits to action: the allocation of individual behavior.__ 1980. Edited by J.E.R. Staddon. Academic Press, New York. 320 pp. U.S. $24.

*__The mitigation symposium: a national workshop on mitigating losses of fish and wildlife habitats.__ 1980. Co-ordinated by Gustav A. Swanson. General Technical Report RM-65. U.S. Department of Agriculture, Fort Collins, Colorado. 685 pp. Free.

__Neusiedlersee: the limnology of a shallow lake in central Europe.__ 1979. Edited by H. Loffler. Monographiae Biologicae, 37. Junk, The Hague. x + 559 pp., illus. U.S. $102.65.

*__Overshoot: the ecological basis of revolutionary change.__ 1980. By William R. Catton, Jr. University of Illinois Press, Champaign. xvii + 298 pp. U.S. $16.50.

__Perspectives on lake ecosystem modeling.__ 1980. Edited by Donald Scavia and Andrew Robertson. Ann Arbor Science, Ann Arbor. 326 pp., illus. U.S. $33.95.

__The River Volga and its life.__ 1979. Edited by P. D. Mordukhai-Boltovskoi. Monographiae Biologicae 33. Junk, The Hague. xvi + 473 pp., illus. U.S. $73.70.

__Shallow lakes: contributions to their limnology.__ 1980. Edited by M. Dokulil, H. Metz, and D. Jewson. Developments in Hydrobiology, 3. Junk, The Hague. 218 pp. U.S. $59.50.

__Sharing nature with children.__ 1980. By Joseph Bharat Cornell, Ananda, Nevada City, California. 144 pp., illus. U.S. $4.95.

†__Transuranic elements in the environment.__ 1980. Edited by Wayne C. Hanson. DOE/TIC-22800. United States Department of Energy, Oak Ridge, Tennessee. xvii + 728 pp., illus. U.S. $18.50.

__A year in the life of a field.__ 1981. By Michael Allaby. David and Charles (Canadian distributor McGraw-Hill Ryerson, Toronto). 192 pp., illus. £7.95.

Miscellaneous

__The art of Canadian nature photography.__ 1980. Edited by J. A. Kraulis. Hurtig, Edmonton. 128 pp., illus. $27.50.

†__Autobiography of John Macoun, Canadian explorer and naturalist, 1831–1920.__ 1980. 2nd edition. Special Publication No. 1. The Ottawa Field-Naturalists' Club, Ottawa. 361 pp. $12.50 plus $2 postage.

__Careers in conservation.__ 1980. By Ada Graham and Frank Graham. Sierra Club, San Francisco. ix + 166 pp., illus. U.S. $9.95.

†__Dictionary of theoretical concepts in biology.__ 1981. By Keith E. Roe and Richard G. Frederick. Scarecrow Press, Metuchen, New Jersey. 380 pp. U.S. $17.50.

__Fossils in the making: vertebrate taxonomy and paleoecology.__ 1980. Edited by Anna K. Behrensmeyer and Andrew P. Hill. Papers from a conference, Austria, 1976. University of Chicago Press, Chicago. xii + 338 pp., illus. Cloth U.S. $18; paper U.S. $7.

Biological sciences at the National Research Council of Canada: the early years to 1952. 1979. By N. T. Gridgeman. Sir Wilfrid Laurier University Press, Waterloo. xxii + 154 pp., illus. $7.50.

Interactions of energy and climate. 1980. Edited by Wilfrid Bach, Jurgen Pankrath, and Jill Williams. Reidel, Dordrecht, Holland. Cloth Dfl. 110; paper Dfl.50.

The kindly fruits of the earth: recollections of an embryo ecologist. 1979. By G. Evelyn Hutchinson. Yale University Press, New Haven. xiv + 264 pp., illus. U.S. $18.50.

McGraw-Hill encyclopedia of ocean and atmospheric sciences. 1980. Edited by Sybil P. Parker. McGraw-Hill, New York. 580 pp., illus. U.S. $34.50.

Practical physics: the production and conservation of energy. 1980. By Joseph F. Mulligan. McGraw-Hill, New York. xvii. 526 pp., illus. U.S. $16.95.

Sensory assessment of water quality. 1980. by B. C. J. Zoeteman. Pergamon Press, Elmsford, New York. 160 pp., illus. U.S. $38.

Sourcebook of hydrologic and ecological features: water resource regions of the conterminous United States. 1980. By R. M. Cushman, S. B. Gough, M. S. Moran, and R. B. Craig. Ann Arbor Science, Ann Arbor. 126 pp. U.S. $24.

The stargazer's bible. 1980. By W. S. Kals. Doubleday, Garden City, New York. viii + 168 pp., illus. U.S. $3.50.

Stars and planets. 1980. By Robin Kerrod. Arco, New York. 125 pp., illus. U.S. $6.95.

†**Water, wells, and ground water supplies in Ontario.** 1980. By Gunther Funk, William A. McClenaghan, and Cyril Holland. Ontario Ministry of the Environment, Toronto. 95 pp., illus. Free.

*Assigned for review
†Available for review

The Ottawa Field-Naturalists' Club

Minutes of the One Hundred and First Annual Business Meeting of The Ottawa Field-Naturalists' Club

The 101st Annual Business Meeting of The Ottawa Field-Naturalists' Club (OFNC) was held in the auditorium of the National Museum of Natural Sciences on 15 January 1980. President R. Taylor called the meeting to order at 20:04, a quorum of 54 persons being present. (The final attendance total of 65 was assumed to be a reflection of the good weather that evening!) The Recording Secretary read the minutes of the 100th Annual Business Meeting, which were approved on motion by E. Beaubien (2nd, E. Dickson).

R. Taylor referred to business arising from the minutes. On the question of whether the Club needs two auditors, a motion to amend the Constitution (as previously published in *The Canadian Field-Naturalist* (CFN) in accordance with Article 23 of the Constitution) was read out by C. Gilliatt and put to the vote. The motion was carried.

A letter was sent to the Munros after the last Annual Business Meeting, thanking them for looking after the Moodie Drive bird feeder for so long. An advertisement was placed in *Trail & Landscape* to find more feeder helpers.

Under 'Correspondence' the President read a memo sent to him by M. Singleton of the Federation of Ontario Naturalists publicizing the *Ontario Naturalist* wetlands issue and asking for OFNC help in building an awareness of this problem throughout the province.

The financial statement was presented by the Treasurer, B. Henson, who pointed out that the major difference between 1979 and 1978 was the expenses for the Centennial projects this year. G. McGee noted that our assets are extremely large and asked what we intended to do with them. C. Gilliatt pointed out that there were still some Centennial projects outstanding to which we have committed $31,000. The Finance Committee would be suggesting worthwhile projects on which to spend our excess funds. A motion to adopt the 1978–1979 financial statement was moved by R. Foxall (2nd, H. L. Dickson) and approved.

The President read the Annual Report of Council, which will be published in *The Canadian Field-Naturalist*. Acceptance of the report was moved by H. L. Dickson (2nd, E. Dickson) and the motion was carried.

H. L. Dickson, Chairman of the Nominations Committee, was called upon by The President to present the slate of officers and Council for 1980. The nominations were as follows:

President: R. Taylor; Vice-President: H. L. Dickson; Treasurer: B. Henson; Recording Secretary: D. F. Brunton; Corresponding Secretary: F. Pope; additional members of Council: R. Bedford, F. Bell, W. J. Cody, E. Dickson, R. A. Foxall, C. Gilliatt, F. Goodspeed, W. Gummer, P. Hall, J. D. Lafontaine, D. Laubitz, H. MacKenzie, J. K. Strang, and K. Taylor.

The proposed slate was approved on a motion by H. L. Dickson (2nd, J. Reddoch). The President expressed his thanks to the outgoing Council members for their work on behalf of the OFNC: Elisabeth Beaubien, ex-chairperson of the Education and Publicity Committee; Charlie Beddoe, ex-chairperson of the Excursions and Lectures Committee during the hectic Centennial year, Jane Proulx (formerly Diceman), Marc Forget, and Valerie Hume, ex-Corresponding Secretary. He expressed particular thanks to Ewen Todd, former OFNC President, who after many years on Council took on the Chairmanship of the Conservation Committee and guided it during a time when an enormous amount was achieved on behalf of the club. C. Gilliatt had expressed the desire to step down as OFNC Vice-President and the President thanked him very much for his assistance both as Vice-President and as chairman of the Finance Committee. D. Laubitz had felt that three years of being recording secretary was enough and the President thanked her for her tremendous help in keeping Council meetings to their agenda.

Gilliatt said that F. M. Brigham had agreed to serve as Club auditor and therefore moved (2nd, W. J. Cody) that Brigham be appointed OFNC Auditor for the 1979–1980 fiscal year (Motion Carried).

It was announced that copies of the *Autobiography of John Macoun* will probably be available in about a month at a cost of about $10. Those interested in being informed of its publication were asked to put their names on a list that would be circulated during the social hour.

The OFNC has been approached by the Nakkertok Ski Club to see if the Club would be interested in sharing the use of a large area of land to which Nakkertok has access. An excursion to the area has been arranged for 9 March 1980 and Council would like to have members' reactions both to the area and to the proposal.

The President stated that he would be away from 19 January to 30 March 1980. He also wished to under-

line Hue MacKenzies's remarks on the hard work of all who contributed towards our tremendously successful Centennial year and the success of the many projects.

E. Beaubien expressed thanks to R. Taylor, on behalf of the OFNC membership, for his work as President during the year.

The meeting was adjourned at 21:00 on motion by H. L. Dickson (2nd, C. Beddoe).

During the social hour slides of various activities that had taken place during Centennial Year were shown.

D. LAUBITZ
Recording Secretary

Report of Council to The Ottawa Field-Naturalists' Club for the Year 1980

Nineteen hundred and eighty was a year of new initiatives for the OFNC, seeing the establishment of a new committee, the reorganization of another, and the reevaluation of our publication policies. The club appears to be entering a new phase in its history, one in which the need to streamline operations and increase organizational efficiency is very important. The club is at an awkward stage in its development . . . almost too large to be managed totally by volunteer labor and perhaps not large enough to support full-time staff. Serious discussions on the need for a permanent OFNC office were held and initial explorations were conducted and will be continued. The club presently enjoys an excellent financial condition, due in large part to careful planning and investments in the past. Discussion continues on ways to utilize these accessible funds for the benefit of OFNC objectives and membership without jeopardizing future financial security.

Roger Taylor presided over club affairs for a second term as OFNC President. During his absence from Canada in February and March, H. L. Dickson, OFNC Vice-President, and R. A. Foxall, past president, adeptly handled presidential duties.

Natural history study groups have been established (under the coordination of H. L. Dickson) to encourage skill development within the membership and to gather additional life sciences data for the Ottawa Region. This program, an important part of early OFNC history but sadly neglected in later years, is being enthusiastically received by club members.

A thorough review of existing publications policies and procedures was conducted by the Ad Hoc Committee on OFNC Publications. The committee tabled its report to Council late in 1980. That report now forms the basis for further discussion and evaluation of publication policies, objectives, and procedures (and their implementation) within the OFNC.

With the closing of the *Ottawa Journal* the superlative bird column of the late John Bird (and subsequently F. M. Brigham and B. Morin) ceased publication. The OFNC approached the *Ottawa Citizen* with suggestions for an additional, broadly based natural history column in that newspaper. Initial responses have been positive.

The OFNC continues to deposit historical club materials in the National Archives. A large quantity of bird data as well as materials from several long-time OFNC members (including the late Herbert Groh) were deposited this year. Members are encouraged to send any OFNC material in their possession which may have historical value to any member of Council; they will see that it gets to the Archives.

The following committee reports are abstracted from presentations made to Council by committee chairpersons (as indicated):

Awards Committee

This committee was established in 1980 to initiate the nomination of deserving OFNC members for awards offered by other organizations and to recognize the achievements of members within the club. This is due to the realization that a tremendous amount of effort by individual members goes into the success of OFNC projects and that such contributions should be recognized. OFNC awards have been established in the following categories:

1) Member of the Year Award
2) OFNC Service Award
3) Naturalist Award
4) Conservation Award

The nomination of OFNC Honorary Members will also fall within the mandate of this committee in the future.

The committee is still in the development stage but we are hopeful that it will become fully functional in 1981.

(H. L. Dickson)

Birds Committee

The Birds Committee underwent a major reorganization in 1980. Formerly the Bird Records Committee which was sponsored by (but not formerly a committee of) the OFNC, the Birds Committee is now responsible for all aspects of birding activity within the club. It includes the Bird Feeder Subcommitee (responsible

for the maintenance of OFNC bird feeders) and the Bird Records Subcommittee (responsible for rare bird reports reviewing and other technical matters). The overall committee has been expanded to meet the needs of this broader mandate.

The committee organized the Spring, Fall, and Christmas Bird Counts in the Region again this year, largely through the efforts of B. Ladouceur. Over 100 observers participated in the Christmas Count, making it one of the largest in Canada. An ad hoc group has been established to evaluate the whole question of bird counts within the OFNC and will be reporting back early in 1981.

Four OFNC bird feeders were maintained in the Region again this year and were enjoyed by thousands of hikers, skiers, and birders from the Ottawa area. Over 635 kg (1400 lb) of seed was consumed by an appreciative clientele! The National Capital Commission (Interpretive Section) has kindly agreed to cover the seed requirement for one of the feeders, thus reducing the increasingly large financial committment for feeder supplies.

The Ottawa Rare Bird Alert and Bird Feeder Inventory were both revised this year. The committee is seriously investigating the possibility of establishing a phone-in 'Bird Hot-line' for the Ottawa Region.

Ten rare bird reports were processed in 1980, including the (accepted) Scissor-tailed Flycatcher report which was the first record for the Ottawa-Hull area. The photo duplicate file of rare bird records was increased substantially in 1980.

The tremendous effort put into the reorganization and programs of the Birds Committee by the various subcommittees and members have really paid off and 1981 should be an extremely successful and productive year for OFNC birding activities.

(D. F. Brunton)

Centennial Committee

The activities of the committee are winding down with the completion of the majority of centennial projects. The *Autobiography of John Macoun* and *Transactions of The Ottawa Field-Naturalists' Club* and *The Ottawa Naturalist: Index* were both published in 1980 and have been well received. Two projects initiated in the Centennial Year (the Naturalists' Guide to the Ottawa Region and Orchids of Ottawa) are on-going. The former at least may be ready for publication late in 1981.

My thanks once more to all of those who have contributed so much time and effort towards the success of the Centennial projects.

(H. MacKenzie)

Conservation Committee

In 1980 the committee found itself devoting a great deal of time to various Regional and Municipal concerns. Briefs and/or plan critiques were presented on a variety of local topics and to a variety of local authorities, including:

Ottawa–Rideau River Corridors Plan (Regional Municipality of Ottawa–Carleton)
Gloucester Official Plan (Gloucester Township)
Gatineau Park Master Plan (National Capital Commission)
Greenbelt Management Plan (National Capital Commission)
Management of conservation lands (Ontario Ministry of Natural Resources)
Bridlewood Buffer Zone (Regional Municipality of Ottawa–Carleton)
Carp Hills development (Regional Municipality of Ottawa–Carleton)
Mer Bleu preservation (Nature Conservancy of Canada)

Communications with the appropriate authorities were also made regarding a number of provincial and/or national issues, including:

Long-range land use in Southern Ontario (Ontario Ministry of Natural Resources)
National Grasslands Park (Environment Canada)
Madawaska River Park Reserve (Ontario Ministry of Natural Resources)
Preservation of Oshawa Second Marsh (Environment Canada, Ontario Environment)
Polar Bear Pass IBP Site protection (Environment Canada)
Niagara Escarpment management & planning (Niagara Escarpment Commission)
Backus Woods preservation (Ontario Ministry of Natural Resources)
Wetlands conservation (Federation of Ontario Naturalists)
BIOP Program: arctic oil spill research (Environment Canada)
Environmental impacts of power line development (Ontario Hydro)

The implications of conservation areas management by the Ontario Ministry of Natural Resources under the authority of the Forestry Act was a major concern of the committee in 1980. Although a great deal of discussion and correspondence with local OMNR personnel took place, little real progress was apparent. There is a serious and fundamental difference in the perception of conservation management ideals and approaches between OMNR management staff and that of OFNC personnel, who are less concerned for commercial forest production. This undoubtedly will remain a major concern of the committee in 1981.

The OFNC was unable to stop the importation of Raccoon-dogs from Europe into southern Ontario but was able to rouse widespread attention to this

potentially devastating situation. The animal is a serious problem for agriculture and wildlife in the Old World. Through contact with Tom MacMillan, P.C. Environment Critic in Parliament, a question on this matter was brought before the House of Commons. It is hoped that our efforts will at least see a strengthening of regulations controlling such potentially dangerous imports in the future.

J. Reddoch of the committee was a main speaker at the York University conference on Natural Areas in 1980. She discussed the highly successful experience of the OFNC regarding the establishment of designated natural areas within the Regional Municipality of Ottawa-Carleton.

The Committee had little time for field work this year (we are hopeful of better in 1981) but did manage to visit the Carp Hills where important life sciences data were gathered.

We are receiving more and more requests from various groups and agencies for support of particular conservation issues. To cope with this, the membership of the committee is increasingly emphasizing provincial and national expertise, in addition to local knowledge. It has been a demanding but largely satisfying year.

I want to thank everyone on the committee for their support and hard work. Their input has made 1980 a very busy but successful year for conservation in the Ottawa Region.

(H. L. Dickson)

Education and Publicity Committee

This was a year for reorganization for the committee. Only two members from the previous year stayed on into 1980. With additional volunteers, however, the committee is now back up to strength.

Early in the year Council was approached for a reevaluation and clarification of the committee's function. After lengthy discussions, it was decided that the committee should concentrate its efforts on helping the people of the Ottawa Region to become more aware of the OFNC and its programs.

Two major displays (at the Billings Estate in June and at the Ottawa Duck Club annual show in November) were planned and managed by the committee and other interested OFNC members. Attendance at both was very good.

Club members selected by the committee selected winners and presented $100 in prize money for the best biological and life sciences exhibits at the Ottawa Regional Science Fair. A subscription to *Trail & Landscape* was also awarded to each winner.

The committee arranged for leaders to conduct outings for several groups, including the Ottawa Girl Guides, Beavers, several school groups, and the Nepean Parks & Recreation Association.

Regular publicity for OFNC activities was established in 1980. This included notifying local newspapers, radio and television stations, and the monthly magazine *What's On in Ottawa*. Because attendance was fairly good over the past year, increased publicity was felt to be unnecessary.

Advertizing for the Macoun Autobiography was a major concern for the committee. With the assistance of Sally Gray, the committee wrote and mailed 800 fliers to individuals and organizations. Review copies were also sent out to selected journals.

The committee assisted George McGee in the revision of the 'Birds, Botany & Geology' brochure that is designed to help visitors to the National Capital. The National Capital Commission is reprinting the publication.

The committee also coordinated efforts to market OFNC sales items. They are now available at all OFNC meetings and special displays. A special Christmas pamphlet of OFNC sales items was included in a mailing of *Trail & Landscape*.

(P. Hall)

Excursions and Lectures Committee

The committee organized 44 excursions, evening meetings, and workshops in addition to the nine monthly meetings of the OFNC, the annual business meeting, and the annual dinner. Bird outings continue to be the most frequent form of excursion . . . 17 in all. Two of those were long-distance outings (to Presqu'il Park, Ontario, and Derby Hill, New York). Five other (general natural history) excursions were also long-distance efforts requiring bus transportation and proved to be very popular. The general-type excursions appear to be increasing in popularity and as such, the relative number of bird outings was reduced in 1980.

Two new types of outings were held this year . . . an overnight excursion to the NCC cabins at Lac Lapeche in Gatineau Park and a midweek bird hike. Both were very successful.

We are pleased to note an increase in monthly meeting attendance (with over 100 in attendance at one meeting).

My thanks to all those who led outings and/or provided excellent monthly meeting presentations. The National Museum of Natural Sciences continues to be of important assistance through their willingness to provide meeting space and other facilities. Their 'Dinobus' provided valuable transportation on several OFNC excursions in 1980 — for which we are most grateful.

(F. Bell)

Finance Committee

Three meetings of the committee were held during the year.

Proposals were made to Council regarding the selling price of OFNC Special Publications (*Autobiography of John Macoun* and *Transactions of The Ottawa Field-Naturalists' Club* and *The Ottawa Naturalist: Index*). In addition, we determined minimal financial reserves that would be required by both the CFN and the OFNC in general. These were established as $20,000 and $12,000, respectively. The general OFNC reserve figure may be somewhat high and will be reevaluated.

The committee recommended the establishment of ad hoc committees to evaluate two possible expenditures of accessible OFNC funds: the establishment of an OFNC scholarship, and the microfilming of all back issues of CFN. The latter group will also examine the worthiness of selling all back numbers of CFN to a dealer, thus reducing inventory.

A budget was proposed to Council for the 1981 fiscal year in October 1980. It calls for revenues of $15,200 and expenditures of $14,470, for a budget surplus of $730. Centennial expenditures amounting to about $9400 are still outstanding.

A new typewriter for the Treasurer's Assistant (costing up to $850) was authorized by Council and will be acquired.

(C. Gilliatt)

Macoun Club Committee

The Macoun Club continues to be important for enthusiastic young naturalists in the Ottawa Region. Most of the credit for the club's success this year must be given to the youngsters themselves. Susan Hulley, Alex Hubbard, and Ian Bell served as Presidents for the Senior, Intermediate, and Junior groups, respectively. Arnet Shepard continued as Club Chairman in 1980 and is due thanks for his important efforts. Through the year he was assisted by Elisabeth Beaubien, Fazal Mohammed, Andrew MacFarlane, and Michael Rankin.

The second annual Macoun Symposium was held last March, concerning such topics as carcinogens, pesticides, nuclear wastes, garage and pulp and paper industry pollution.

Weekend outings were characterized by rainy weather, but this did not dampen the enthusiasm of the participants. Many of the outings were to the Club's study area near Moodie Drive or to the Conroy Road Nature Trail. Other trips were held too, including a tour of the Carleton University greenhouses and a trip to the Adirondack Mountains of northern New York State.

Projects this year included the overhauling of the library card catalogue, the establishment of a club herbarium, and continued investigations in the study area.

Rod Story was awarded the 1980 Baldwin Scholarship and the $150 prize that goes with it.

A meeting between OFNC and National Museum of Canada personnel was held in November to discuss the level of Museum participation in Macoun Club activities. It was agreed that the Club was a worthwhile venture and that Museum staff should become more directly involved; this involvement should be formalized.

With the continued support of the National Museum of Natural Sciences and the direction received from the OFNC, the Club should continue its successful program through the 1980s.

(K. Taylor)

Membership Committee

On 1 December 1980, OFNC records listed 1220 members, compared with 1198 in December 1979. This modest increase continues the trend of recent years.

This year the OFNC was proud to elect four new Honorary Members:

Clarence Frankton, Ottawa, Ontario
Yorke Edwards, Victoria, British Columbia
Mary E. Stuart, Ottawa, Ontario
Douglas B. O. Savile, Ottawa, Ontario.

Membership	Canadian (local)	Canadian (other areas)	USA	Foreign	Total
Individual	460 (455)	337 (339)	93 (96)	4 (3)	894 (893)
Family	233 (219)	26 (29)	1 (1)	4 (1)	261 (250)
Sustaining	15 (15)	3 (1)	—	—	18 (16)
Life	13 (12)	14 (12)	3 (3)	2 (2)	32 (29)
Honorary	9 (6)	5 (4)	1(–)	—	15 (10)
Total	730 (707)	385 (385)	98 (100)	7 (6)	1220 (1198)
Change	+23	—	–2	+1	22

Figures in parenthesis represent 1979

We thank the more than 60 members who offered their services by filling in the questionnaire on the back of the 1979 membership renewal form. We propose to have this (and other volunteer information) coded into our computer file in 1981 so that committees seeking volunteers can have up-to-date information.

I thank all committee members for their willing efforts, with a special thank you to Ellaine Dickson, who voluntarily devotes so much time and energy to maintaining OFNC membership records and ensuring that our computer file is up to date . . . along with her many other Club interests and responsibilities.

(F. Goodspeed)

Publications Committee

Three publications fall within the responsibilities of the committee; *The Canadian Field-Naturalist, Trail & Landscape,* and *The Shrike.*

The Canadian Field-Naturalist was published in four issues comprizing Volume 94, Issues 1 to 4, with a total of 43 articles, 40 book reviews, and 44 notes. A listing of 285 new titles related to the interests of the readership was also provided. We were able to publish this year without financial assistance from a scientific publications grant, primarily due to a higher rate of payment of page charges by contributors.

Trail & Landscape was published as Volume 14, Issues 1 to 4, containing Club news and articles related to natural history and conservation in the Ottawa Region. A total of 184 pages of material was published.

The Shrike contains seasonal summaries of bird sightings in the Ottawa Region and news of interest to local birders. It has gone through a difficult period in 1980 but is now back on track and will be on a solid footing in 1981.

Both the *Autobiography of John Macoun* and *Transactions of The Ottawa Field-Naturalists' Club* and *The Ottawa Naturalist: Index* were made available in 1980. They mark the inauguration of the "Special Publications" of the OFNC. This designation will be applied to future publications sponsored by the Club when they are of significant value.

(J. K. Strang)

By the end of 1981 we should be reporting that many of the 'loose ends' identified above have been wrapped up. The OFNC is moving steadily towards a more stable and secure status, both financially and organizationally, while at the same time enhancing the field-naturalist orientation that has been our strength and tradition for over a century. It has been a productive, exciting, and (at times) controversial year in OFNC history. The momentum established in 1980 is truly an appropriate and satisfying start to the new decade.

DANIEL F. BRUNTON
January 1981 Recording Secretary

Auditor's Report

To: Members of The Ottawa Field-Naturalists' Club

I have examined the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1980, and the related Income Statements for the year then ended. My examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary under the circumstances.

In my opinion, these financial statements present fairly the financial position of the organization as at September 30, 1980, and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

December 3, 1980 (Signed) F. Montgomery Brigham

The Ottawa Field-Naturalists' Club Balance Sheet

as of September 30, 1980

Assets

Current			
Cash and term deposits		$49,250.62	
Accounts receivable		10,693.69	
Accrued interest		1,448.51	
Prepaid expenses		650.00	$62,042.82
Fixed at cost			
Equipment		529.50	
Less accumulated depreciation		469.00	60.50
Total Assets			$62,103.32

Liabilities and Surplus

Current liabilities			
Accounts payable		$1,758.79	
Deferred income		7,413.00	$9,171.79
Memorial funds			
Baldwin		197.50	
Father Banim		50.00	247.50
			$9,419.29
Surplus			
Balance October 1, 1979		$58,902.99	
Add: income over expenditure			
The Ottawa Field-Naturalists' Club	$3,913.17		
The Canadian Field-Naturalist	5,281.53		
	9,194.70		
Less: net expenditure — Centennial projects	15,413.66	6,218.96	
Balance September 30, 1980			52,684.03
Total liabilities and surplus			$62,103.32

The Ottawa Field-Naturalists' Club
Statement of Income and Expenditure

for the year ended September 30, 1980

Income			
Apportionment of membership fees			
Annual	$7,524.00		
Life	234.00	$7,758.00	
Trial & Landscape			
Subscriptions	370.00		
Back numbers	102.00	472.00	
Shrike subscriptions		490.00	
Donations		550.55	
Interest		2,549.51	$11,820.06
Expenditure			
Trail & Landscape			
Publishing	3,402.55		
Circulation	221.74		
Editing and Office	129.21		
Honoraria	415.00	$4,168.50	
Shrike publishing and expenses		336.01	
Committee activities — net			
Excursions and lectures	(89.79)		
Membership	823.65		
Macoun Club	149.74		
Conservation	28.85		
Bird Records	5.54		
Bird Feeders	628.69		
Publicity	17.00		
Orchid survey	55.76	1,619.44	
Baldwin Scholarship	150.00		
Special Activities	258.22		
Council Expenses	368.41		
Office Assistant	300.00		
Office Supplies	607.37		
Miscellaneous	98.94	1,782.94	7,906.89
Excess of income over expenditure			$3,913.17

The Ottawa Field-Naturalists' Club
Statement of Centennial Project Expenditures

for the year ended September 30, 1980

	1979–1980		1980	
Recording — Songs of the seasons				
Revenue	$7,887.45		$3,861.91	
Expenditure	6,966.76	$ (920.59)	1,047.64	$(2,814.27)
Club pin				
Revenue	207.20		47.60	
Expenditure	1,188.36	981.16		(47.60)
Bird record cards				
Revenue	169.75		91.00	
Expenditure	405.95	236.20		(91.00)
Hasti-notes				
Revenue	61.60		2.80	
Expenditures	89.07	27.47		(2.80)
Macoun autobiography reprint				
Revenue	2,700.00		2,700.00	
Expenditure	10,079.50	7,379.50	9,561.04	6,861.04
CFN Index				
Revenue	225.00		225.00	
Expenditure	10,484.50	10,259.50	10,484.50	10,259.50
Club T-shirts				
Revenue	10.00		10.00	
Expenditure	185.90	175.90	185.50	175.90
Orchids of the Ottawa District		1,072.89		1,072.89
Projects completed in 1979	2,589.49			
Less donations	827.72	1,761.77		
Net expenditure		$20,973.80		$15,413.66

The Ottawa Field-Naturalists' Club
Statement of Income and Expenditure — *The Canadian Field-Naturalist*

for the year ended September 30, 1980

Income			
Apportionment of membership fees			
Annual	$5,014.00		
Life	156.00		
	5,170.00		
Subscriptions	15,421.40	$20,591.40	
Publication			
Reprints	6,120.60		
Plates and Tab Setting	2,618.00		
Extra Pages	12,257.20		
Back Numbers	616.49	21,612.29	
Other — interest	5,892.56		
exchange	722.09	6,614.65	$48,818.34
Expenditure			
Publishing	$28,792.67		
Reprints	4,292.96	$33,085.63	
Circulation		4,770.71	
Editing and Expenses		1,187.30	
Office Assistant		1,890.00	
Postage		688.15	
Office Supplies		401.02	
Honoraria		1,473.00	
Miscellaneous		41.00	$43,536.81
Excess of income over expenditure			$ 5,281.53

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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 95, Number 4

October-December 1981

The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

Patrons

Their Excellencies the Governor General and Mrs. Edward Schreyer

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

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The Canadian Field-Naturalist

The Canadian Field-Naturalist is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

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Subscriptions and Membership

Subscription rates for individuals are $13 per calendar year. Libraries and other institutions may subscribe at the rate of $25 per year (volume). The Ottawa Field-Naturalists' Club annual membership fee of $13 includes a subscription to *The Canadian Field-Naturalist.* Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists' Club, Box 3264, Postal Station C, Ottawa, Canada K1Y 4J5.

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Back Numbers

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club,* 1879-1886, and *The Ottawa Naturalist,* 1887-1919, may be purchased from the Business Manager.

Cover: Smith's Longspur, *Calcarius pictus,* female photographed at nest in the Chilkat Pass area, British Columbia, by Earvio Siam (British Columbia Provincial Museum Photo No. 661). See Note by Martin, Hannon and Moses p. 469.

The Canadian Field-Naturalist

Volume 95, Number 4 October-December 1981

Announcement

The Ottawa Field-Naturalists' Club is pleased to announce the appointment of Dr. Francis R. Cook as Editor of *The Canadian Field-Naturalist* starting with this issue. Dr. Cook, a former editor (1962-1966) and associate editor (1972-1981) of *The Canadian Field-Naturalist,* is Curator, in the Herpetology Section, at the National Museum of Natural Sciences (1960-). The appointment was made after a lengthy search involving consultation with many natural history experts across Canada. We are confident that under Dr. Cook's editorship *The Canadian Field-Naturalist* will continue to maintain its high standards.

In 1979 an ad hoc committee was appointed to examine and to make recommendations concerning all aspects of existing Ottawa Field-Naturalists' Club periodicals; in particular *The Canadian Field-Naturalist, Trail and Landscape,* and *The Shrike.* The Executive Committee of the Council is preparing a detailed publication policy of the Ottawa Field-Naturalists' Club based on the ad hoc committee report and its subsequent reviews. When ready, it will be published in *The Canadian Field-Naturalist.* Readers can be assured that the Club will continue to publish *The Canadian Field-Naturalist* and to provide the support necessary to maintain the present standard of excellence.

ROGER TAYLOR
President, The Ottawa Field-Naturalists' Club

R. E. BEDFORD
Chairman, Publications Committee

Grazing Intensity Effects on the Breeding Avifauna of North Dakota Native Grasslands

H. A. KANTRUD

Northern Prairie Wildlife Research Center, P.O. Box 1747, Jamestown, North Dakota 58401

Kantrud, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Canadian Field-Naturalist 95(4): 404–417.

A breeding bird census and plant survey was conducted on 180 samples of lightly, moderately, and heavily grazed and hayed native grasslands in North Dakota in 1974. The ten most important cover plants on each of eight major physiographic landforms in three of the four regions (the Agassiz Lake Plain excluded) overlapped so extensively that only 19 species were involved: 13 grasses or sedges, four forbs, one shrub, and one clubmoss. Bird densities were generally highest in (i) regions and landforms containing numerous natural basin wetlands, (ii) flatter, glaciated landforms containing more fertile soils, and (iii) landforms of greater relief and high habitat heterogeneity. Avian species richness tended to decrease with increased grazing intensity, but total bird density increased due to higher populations of a few species, and hayland that had been mowed and raked during the previous growing season was highly attractive to some species.

Key Words: Grassland birds, North Dakota, landforms, soils, vegetation, grazing, mowing.

Grasslands in North Dakota have evolved under varying climatic, geomorphologic, and edaphic conditions. There are differences in the type and genesis of the various physiographic landforms created by Pleistocene glaciation. Studies of the avian communities on different glacial landforms on the Northern Great Plains and Interior Lowlands have not been undertaken. This study was initiated because of the rapid destruction of native grasslands in North Dakota, the extent of which varies greatly by landform. For conservationists, it is important to know the general floral and faunal composition of the remaining grassland areas before protective measures are undertaken. In this report, I describe differences in the density and species richness of breeding birds on variously grazed native grasslands throughout the state of North Dakota.

The surface of North Dakota generally slopes downward, from 1069 m above sea level in the southwestern corner of the state to 230 m above sea level in the northeast corner. Deposits of sediment and till related to Wisconsinan glaciation cover about 75% of the state lying north and east of the Missouri River; earlier glaciations covered an additional 12% of the state but their deposits have nearly been eliminated by subsequent erosion. The Missouri Coteau divides the state, with the Central Lowland lying east of it and the Great Plains lying to the west of it. Additional details of state geology may be found in Bluemle (1977).

North Dakota has been classified into various regions and subregions based on physiography and the biota (Stewart and Kantrud 1972, 1973; Stewart 1975). I recognize four regions in this report (Figure 1). The 13 landforms on which samples were located are based on Bluemle (1977, and personal communication), and are described in Appendix A.

Methods

Selection of Sample Units

One hundred and eighty samples of uncultivated native grassland were selected (Figure 1), in numbers roughly proportional to the areas of the several physiographic landforms (Table 1) within the four major physiographic regions of the state. Some landforms occur in more than one region. There were 21 combinations of region and landform.

Sample site locations were initially selected at random from numbered legal townships, sections, and quarter-sections within each of the 21 strata. However, if a selected area was devoid of native grassland, the nearest example on the desired landform was chosen. Many sites were rejected because field examination revealed old furrows, rockpiles, domestic grass plantings, or other evidence of past disturbance by cultivation. Although most of the 180 sites were legal quarter-sections (65 ha, 160 acre), several as large as a section (259 ha) or as small as 16 ha were also utilized. Most sites were square but occasionally it was necessary to utilize odd-shaped areas.

Bird Censuses

Field work was conducted by two teams, each consisting of a botanist and an ornithologist. The breeding bird census began 22 May and ended 19 July 1974. This period includes the peak nesting season for nearly all species studied (Stewart 1975). Bird censuses were conducted from sunrise to sunset when temperatures did not exceed 32°C, precipitation did

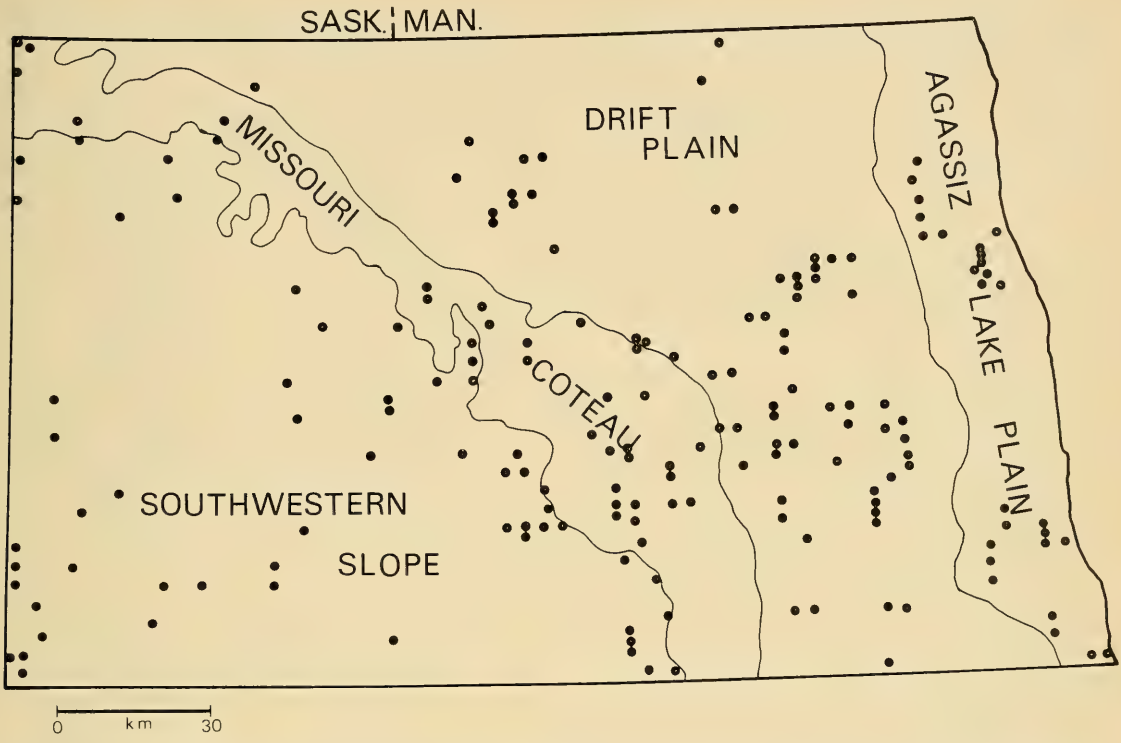

FIGURE 1. Major physiographic regions of North Dakota showing location of sample plots. Physiographic landforms cannot be shown at this scale because of their extremely complex pattern and small size.

not occur, and sustained wind velocities did not exceed 24 km/h.

Järvinen et al. (1976) found no temporal changes in bird observability on transects in open fields and meadows. Comparison of five 3-h time periods (0600-2100) in our study revealed that (i) peak densities for at least three species occurred during each of the periods, and (ii) the largest decrease in total bird registrations compared to the peak counts at 0900-1200 h was only 37% during the period 1800-2100 h. Temporal variation in bird counts undoubtedly influenced the density indices for many species but was not considered a serious problem because of the random way we conducted our censuses.

Analyses based on single censuses are not recommended during intensive studies where population estimates are required but have been used successfully to derive indices to populations or multispecies diversity measurements during extensive surveys (Robbins and Van Velzen 1967; Stewart and Kantrud 1972; United States Department of Interior and Canadian Department of Environment 1977; Rotenberry 1978). Speirs and Orenstein (1967) have shown that, in open Ontario habitats, average efficiency of single censuses is 66-76% that of 6-10 temporally spaced censuses in estimating breeding populations. I felt justified in basing indices to bird density on single counts in the grassland habitats because most of the species possess behavioral adaptations, including lengthy, loud, and often elaborate flight songs, perch songs, and synchronous displays, that tend to greatly increase their detectability compared to birds inhabiting wooded areas. Birds are also rather easily flushed in grasslands. The large areas of the sample plots also resulted in relatively high absolute numbers of bird observations per plot. However, I caution against the use of single censuses in studies where precise population estimates are desired.

All species were identified in the field by sight or sound. Counts were based primarily on number of pairs as indicated by territorial males or segregated pairs. Each male Red-winged Blackbird (polygynous) or Brown-headed Cowbird (promiscuous) was considered to represent only one pair. Single raptors, grouse, shorebirds, and nighthawks on a sample plot were considered to represent a pair, but if more than one was observed the total was halved and rounded to the nearest lower integer. Additional details on

TABLE 1—General features of the major physiographic regions of North Dakota. The number of plots (total 180) on which bird censuses and vegetative surveys were conducted are shown for the predominant physiographic landforms within each region.

	Region				
	Southwestern Slope	Missouri Coteau	Drift Plain	Agassiz Lake Plain	
A. Topography	broadly rolling	hilly	gently undulating	flat	
Drainage integration	well	poor	moderate	moderate	
Basin wetlands	few	many	many	few	
Characteristic soils[a]	typic borolls	typic and udic borolls	udic borolls	udic borolls	
Elevation ($\bar{x}$ m above sea level)[b]	730	580	460	270	
Thickness of glacial sediments	thin or absent	very thick	thick	thick	
Precipitation ($\bar{x}$ cm/yr)[c]	37	41	44	50	
Height of dominant upland grasses & sedges[d]	short, mid	mid, short	mid, short	tall, mid	
B. Thirteen physiographic landforms/No. of plots					Total
Ground moraine			19	6	25
Terminal moraine		12	12		24
Lake plain	3		14	6	23
Glacial outwash deposits	11		9		20
Eolian sand deposits	8		4	5	17
Unglaciated bedrock	17				17
Dead-ice moraine		16			16
Kames	3		8		11
Sheet moraine	10				10
Glaciated bedrock	5				5
Lake shore deposits				5	5
Deltaic deposits				4	4
Alluvial river deposits				3	3
Total no. of sampled plots	57	28	66	29	180

[a]Borolls are frigid soils (mean annual temperature $<8°$ C) with nearly black surface horizons high in organic matter and bases. Udic borolls have greater than average soil moisture than typical (typic) borolls (Aandahl 1972).
[b]From Bluemle (1977) and personal communication.
[c]From Jensen (n.d.).
[d]From Stewart (1975).

determination of breeding status have been described previously (Stewart and Kantrud 1972).

The verges of many plots bordered other habitat types. To reduce the influence of birds occupying fencelines or adjacent habitats, census transects were restricted to the interior of each plot except in the case of the few that were less than 65 ha in area. The "hollow square" technique of Speirs and Orenstein (1967) was used on the standard 65 ha plots; the 1609 m (1 mile) transect route used lay 201 m inside the boundary (Figure 2). Birds were counted within 101 m of the route, yielding an areal coverage of 31.5 ha. Transect routes were variable on plots of other sizes and shapes.

Transects were walked at a standard speed of 40 m/min. Indices to bird density were expressed in pairs/min $\times 10^3$, allowing standardization of data from plots of unequal size and shape. The technique of expressing bird densities in units of time has been used in similar extensive studies (e.g. Grinnell and Storer 1924; Skinner 1975).

The phenology during late spring and early summer is about two weeks earlier in southwestern North Dakota than in the northeastern portion of the state.

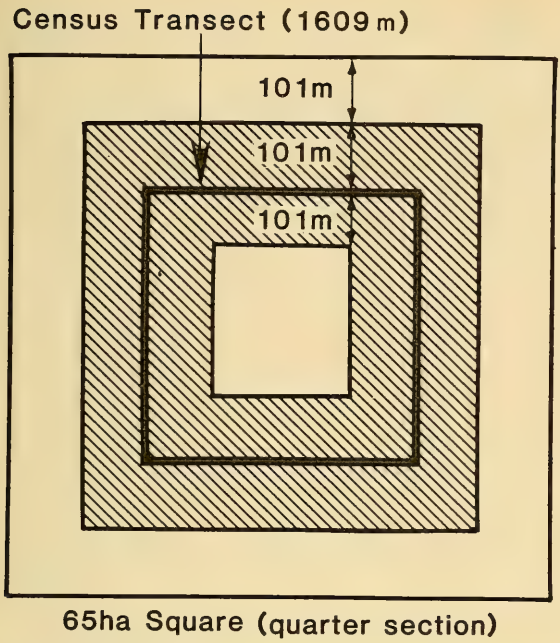

FIGURE 2. Quarter section sample plot showing transect route. Shaded areas censused = 31.5 ha.

The effects of these differences on within-season variations in the bird censuses were partially compensated for by beginning the survey in the southwestern part of the state; plots were then visited sequentially on a broad front moving toward the northeast.

The scientific names of the bird species are provided only in Table 2.

Vegetation Surveys

A rapid field reconnaissance of the vegetation was conducted immediately after the bird census on each plot. An areal cover index was assigned to each species on the plot. The cover classes and range of cover (%) in each class were as follows: (1) 0–1, (2) 1–10, (3) 10–25, (4) 25–50, (5) 50–75, (6) 75–90, (7) 90–100. Class midpoint values were used in the analysis. Scientific names of plants follow the Atlas of the Flora of the Great Plains (Great Plains Flora Association 1977).

Land-Use

Grazing intensity was estimated by comparing the percentage bare soil, amount of standing and fallen dead vegetation, and average vegetative height on the study plots with that of nearby protected or ungrazed areas. Based on the above information, plots were placed into three subjective categories: heavily, moderately, and lightly grazed.

Seven of the 180 plots consisted of native grassland used for hay. These plots had been mowed and raked in 1973, but not yet mowed in 1974 at the time of census.

All categories of grazing were represented in each of the four regions. Hayland was represented in all but the Southwestern Slope region.

Results

All of the bird species considered in this report nest below, at, or slightly above the ground in moist to dry grasses or low shrubs. Many species also breed in vegetation other than grassland or select other types of nest sites.

Statewide, the five most abundant species were the Chestnut-collared Longspur (34% of the total indicated pairs), Western Meadowlark (12%), Clay-colored Sparrow (10%), Savannah Sparrow (8%), and Horned Lark (6%), totalling 70% of the avifauna.

In the following sections the occurrence of birds is considered (i) for the four physiographic regions, (ii) the nine most important landforms, and (iii) the four land-use categories.

Physiographic Regions

Avian abundance and species composition among the four physiographic regions are shown in Table 2. Total bird density and species richness followed similar patterns, with highest values occurring in the two central regions, and lowest values in the Agassiz Lake Plain. The number of species recorded in each region showed rather wide variation, ranging from 28 in the Drift Plain to 19 in the Agassiz Lake Plain.

Nine of the 30 species have a limited distribution among the regions of the state as indicated by the maps of Stewart (1975): (1) Long-billed Curlew and McCown's Longspur presently occur only in the extreme western part of the state but formerly were common farther east; (2) Ferruginous Hawk occurs regularly in the Southwestern Slope and Missouri Coteau and appears to be reestablishing breeding populations in the Drift Plain region; (3) Sprague's Pipit, Lark Bunting, and Baird's Sparrow are rare or local in the Agassiz Lake Plain region; (4) Marbled Godwit, Short-billed Marsh Wren, and LeConte's Sparrow occur regularly in the three easternmost regions but are rare or absent in the Southwestern Slope. The results of our study fully support Stewart's (1975) conclusions regarding the nine aforementioned species.

Several species which occurred in all regions showed increases or decreases across the regional gradient. From west to east, densities of Killdeer, Western Meadowlark, Red-winged Blackbird, and Savannah Sparrow increased, whereas Horned Lark and Chestnut-collared Longspur showed reduced density.

TABLE 2. Density indices (mean pairs/min × 10^3) and species richness of 30 grassland birds among major physiographic regions and land-use types in North Dakota, 1974.

	Region				Land-use			
Species No. of plots →	South-western Slope (57)	Missouri Coteau (28)	Drift Plain (66)	Agassiz Lake Plain (29)	Heavily Grazed (53)	Moder-ately Grazed (63)	Lightly Grazed (57)	Hayland Mowed 1973 (7)
Ferruginous Hawk (*Buteo regalis*)	0	3	T[b]	*[a]	1	1	0	0
Marsh Hawk (*Circus cyaneus*)	3	3	1	0	2	2	1	0
Sharp-tailed Grouse (*Pedioecetes phasianellus*)	1	0	T	T	0	T	1	0
Killdeer (*Charadrius vociferus*)	5	6	14	22	16	9	8	15
Long-billed Curlew (*Numenius americanus*)	1	*	*	*	0	0	1	0
Upland Sandpiper (*Bartramia longicauda*)	3	10	18	18	20	7	11	13
Willet (*Catoptrophorus semipalmatus*)	2	4	3	0	4	1	1	0
Marbled Godwit (*Limosa fedoa*)	*	1	3	14	3	3	5	4
Wilson's Phalarope (*Steganopus tricolor*)	3	1	10	11	6	4	7	30
Mourning Dove (*Zenaida macroura*)	8	5	10	20	13	7	12	0
Burrowing Owl (*Athene cunicularia*)	1	0	1	0	1	1	0	0
Common Nighthawk (*Chordeiles minor*)	1	0	2	0	1	0	2	0
Horned Lark (*Eremophila alpestris*)	92	67	61	3	154	41	9	0
Short-billed Marsh Wren (*Cistothorus platensis*)	*	0	1	13	0	0	3	0
Sprague's Pipit (*Anthus spragueii*)	10	16	13	*	11	15	6	0
Common Yellowthroat (*Geothlypis trichas*)	5	32	4	10	0	8	18	33
Bobolink (*Dolichonyx oryzivorus*)	4	3	19	73	0	7	39	145
Western Meadowlark (*Sturnella neglecta*)	118	140	146	167	130	146	136	189
Red-winged Blackbird (*Agelaius phoeniceus*)	15	30	38	101	17	34	61	80
Brown-headed Cowbird (*Molothrus ater*)	31	74	68	45	62	49	51	56
Dickcissel (*Spiza americana*)	1	0	1	0	0	1	1	0
Lark Bunting (*Calamospiza melanocorys*)	72	47	15	*	25	57	27	0
Savannah Sparrow (*Passerculus sandwichensis*)	12	34	99	295	33	59	147	412
Grasshopper Sparrow (*Ammodramus savannarum*)	63	65	76	32	40	74	75	43

TABLE 2. (concluded)

	Region				Land-use			
Species No. of plots →	Southwestern Slope (57)	Missouri Coteau (28)	Drift Plain (66)	Agassiz Lake Plain (29)	Heavily Grazed (53)	Moderately Grazed (63)	Lightly Grazed (57)	Hayland Mowed 1973 (7)
Baird's Sparrow (*Ammodramus bairdii*)	37	73	62	*	29	57	49	59
LeConte's Sparrow (*Ammospiza leconteii*)	*	0	T	4	0	0	2	7
Vesper Sparrow (*Pooecetes gramineus*)	16	6	19	8	14	19	12	0
Clay-colored Sparrow (*Spizella pallida*)	56	166	155	61	65	135	139	0
McCown's Longspur (*Calcarius mccownii*)	1	*	*	*	0	1	0	0
Chestnut-collared Longspur (*Calcarius ornatus*)	529	505	370	12	606	422	170	87
Index of total bird density (Mean pairs/min $\times 10^3$/plot)	1094	1290	1210	911	1254	1160	1001	1173
Species richness (Mean no. species/plot)	6.18	7.14	7.27	6.90	6.28	7.03	7.11	7.29

[a]Asterisks indicate region(s) in which species currently is rare or absent (Stewart 1975).
[b]T = density < 0.5.

The Southwestern Slope supported distinctly higher concentrations of two species: Horned Lark and Lark Bunting. In the Missouri Coteau, Sprague's Pipit and Common Yellowthroat were noticeably commoner than elsewhere. The Agassiz Lake Plain had the highest number of species (nine) reaching their greatest density: Killdeer, Marbled Godwit, Mourning Dove, Short-billed Marsh Wren, Bobolink, Western Meadowlark, Red-winged Blackbird, Savannah Sparrow, and LeConte's Sparrow. Species showing strongest attraction to the grasslands in the two central regions, the Missouri Coteau and Drift Plain, were Brown-headed Cowbird, Baird's Sparrow, and Clay-colored Sparrow. The Drift Plain and Agassiz Lake Plain shared equally high values for densities of Upland Sandpiper and Wilson's Phalarope.

Physiographic Landforms

Landforms in which 10 or more plots were censused, regardless of region, are compared for mean density of total birds and species richness in Table 3. Total bird density was more variable than species richness among landforms. Glacial outwash deposits, dead-ice moraine, and ground moraine supported

TABLE 3. Total bird density index and species richness on nine major physiographic landforms in four physiographic regions in North Dakota, 1974[a].

Land Form	No. of sample plots	Total bird density index (mean pairs/min $\times 10^3$/plot)	Mean no. species/plot
Glacial outwash deposits	20	1436	8.35
Dead-ice moraine	16	1434	8.31
Ground moraine	25	1350	7.60
Lake plain	23	1238	7.74
Terminal moraine	24	1182	6.04
Sheet moraine	10	1123	5.30
Kames	11	1088	5.27
Eolian sand	17	816	6.41
Unglaciated bedrock	17	810	5.29

[a]See Table 1 for distribution of landforms among regions.

highest densities of breeding grassland birds. Intermediate densities occurred on lake plain, terminal and sheet moraine, and kames. Total bird density was much lower on eolian sand and unglaciated bedrock. Species richness reached highest values on glacial outwash deposits and dead-ice moraine, was intermediate on lake plain and ground moraine followed by eolian sand and terminal moraine, and was lowest on kames, unglaciated bedrock, and sheet moraine.

Comparisons of use of landforms at the species level are shown in Table 4 by region, but only landforms in which 10 or more plots were censused in any region are included. Species comparisons are valid within and among regions but the landforms listed may not represent the optimum landform for a species because only major landforms are listed.

In the Southwestern Slope region, grasslands developed over glacial outwash deposits supported a denser and richer avifauna than those developed over sheet moraine or unglaciated bedrock. Most of the increased use of outwash deposits was attributable to high concentrations of Red-winged Blackbird,

TABLE 4. Density indices (mean pairs/min × 10^3) and species richness of 29 grassland birds among eight major physiographic landforms within three physiographic regions of North Dakota, 1974[a].

	Southwestern Slope Region			Missouri Coteau Region		Drift Plain Region		
	Glacial outwash deposits	Sheet moraine	Unglaciated bedrock	Dead-ice moraine	Terminal moraine	Ground moraine	Lake plain	Terminal moraine
Species No. of plots →	(11)	(10)	(17)	(16)	(12)	(19)	(14)	(12)
Ferruginous Hawk				2	4			
Marsh Hawk	5	4	1	3	2		4	
Sharp-tailed Grouse		4					1	
Killdeer	11		5	9	2	9	23	25
Long-billed Curlew			5					
Upland Sandpiper	9		1	14	5	2	33	50
Willet	2		1	6		3	9	
Marbled Godwit				1			10	2
Wilson's Phalarope	9			2		11	25	
Mourning Dove	8	11	5	6	3	7	15	9
Burrowing Owl	3	4				3		
Common Nighthawk	2		1					
Horned Lark	101	33	141	79	50	23	76	101
Short-billed Marsh Wren						1	1	
Sprague's Pipit	12	23	4	27		15	28	
Common Yellowthroat	6	8		17	52	8	8	
Bobolink	17		3	6		12	15	12
Western Meadowlark	128	76	134	143	137	154	129	183
Red-winged Blackbird	40	3		22	41	21	71	40
Brown-headed Cowbird	70	35	3	87	56	66	77	104
Lark Bunting	81		44	52	40	8		7
Savannah Sparrow	44	7	7	29	41	156	114	34
Grasshopper Sparrow	53	52	61	84	40	136	59	50
Baird's Sparrow	111	23	26	119	12	122	75	6
LeConte's Sparrow							4	
Vesper Sparrow		9	30	1	13	5	8	23
Clay-colored Sparrow	81	106	2	138	205	118	106	177
McCown's Longspur			5					
Chestnut-collared Longspur	782	723	329	586	397	462	316	443
Index of total bird density (mean pairs/min × 10^3/plot)	1575	1123	810	1434	1099	1342	1207	1266
Species richness (mean no. species/plot)	8.91	5.30	5.29	8.31	5.58	7.32	9.07	6.50

[a]Dickcissel is omitted from this table because it did not occur on the landforms shown.

Brown-headed Cowbird, Lark Bunting, Savannah Sparrow, Baird's Sparrow, and Chestnut-collared Longspur. Sheet moraine was especially attractive to Sprague's Pipit and Clay-colored Sparrow. Grasslands developed over unglaciated bedrock supported noticeably high numbers of Horned Lark and Vesper Sparrow and they were the only grasslands in the state harboring breeding populations of Long-billed Curlew and McCown's Longspur.

In the Missouri Coteau region, values of both multispecies measures were higher on dead-ice moraine than on terminal moraine. Most of the increased use of the former landform was due to higher population densities of Sprague's Pipit, Grasshopper Sparrow, Baird's Sparrow, and Chestnut-collared Longspur. However, terminal moraine was important for a few species including Common Yellowthroat, Vesper Sparrow, and Clay-colored Sparrow.

Major landforms in the Drift Plain were less variable in total bird density and species richness than in the other two regions. Grasslands developed over ground moraine supported slightly greater total bird density but lake plain was highest in species richness. Noticeably higher numbers of Savannah, Grasshopper, and Baird's Sparrow occurred on ground moraine, while lake plain was especially attractive to Marbled Godwit, Wilson's Phalarope, Sprague's Pipit, and Red-winged Blackbird. Terminal moraine supported highest densities of Upland Sandpiper, Horned Lark, Western Meadowlark, Brown-headed Cowbird, and Clay-colored Sparrow.

Land-Use

Density indices for breeding birds are related to four categories of land-use in Table 2. Although the total number of tracts of hayland censused was small (7), this habitat has been included because of its apparently strong attractiveness or aversiveness to some species.

Mean density of birds tended to increase as grazing intensity increased but species richness tended to decrease. Of the three grazing types, heavily grazed areas supported only 22 species compared to 26 and 27 for moderately and lightly grazed areas, respectively. Grassland mowed at the end of the previous growing season but currently unmown at time of the census supported a density of birds comparable with the moderately grazed areas, but was slightly higher in species richness than any of the grazed areas.

Heavily grazed grasslands were especially attractive to Killdeer, Upland Sandpiper, Horned Lark, and Chestnut-collared Longspur. The two latter species comprised almost two-thirds (61%) of the total bird density on these areas. In addition, Sprague's Pipit apparently preferred both heavily and moderately grazed plots over lightly grazed plots.

Only one species, the Lark Bunting, showed a strong tendency to attain peak density under moderate grazing. Three common sparrows, including Grasshopper, Baird's, and Clay-colored, were about equally highly abundant under both moderate and light grazing. Four species, including Common Yellowthroat, Bobolink, Red-winged Blackbird, and Savannah Sparrow showed much higher densities under light grazing.

Species attracted to hayland that had been mowed the previous year included Wilson's Phalarope, Common Yellowthroat, Bobolink, Western Meadowlark, Red-winged Blackbird, and Savannah Sparrow. Grasslands under this type of land-use were avoided by Mourning Dove, Horned Lark, Sprague's Pipit, Lark Bunting, Vesper Sparrow, and Clay-colored Sparrow.

Vegetation

Dominant plants of the major physiographic landforms are shown in Table 5. Among the grasses, *Poa pratensis*, an introduced species, greatly dominated the flora in central and eastern North Dakota. Among the native grasses, *Bouteloua gracilis, Koeleria pyramidata*, and *Stipa comata* were important in all major landforms in the three westernmost regions.

Agropyron smithii was important in all regions but was replaced by *A. caninum* on eastern lake plain. Native grasses of importance primarily in eastern regions included *Andropogon scoparius* and *Stipa viridula*. Two short grasses, *Buchloe dactyloides* and *Festuca octoflora*, were important only in the west. Three short carices (*Carex eleocharis, C. filifolia, C. pensylvanica*) were important in two or more regions.

The short clubmoss, *Selaginella densa*, was an important floral component on outwash deposits in the Southwestern Slope and on dead-ice moraine in the Missouri Coteau. *Symphoricarpos occidentalis* was the only shrub of importance on the major physiographic landforms. It was found in especially large amounts on landforms in the Drift Plain and Missouri Coteau. The only forbs of importance included *Antennaria rosea* on lake plain in the Drift Plain region and *Plantago patagonica, Psoralea argophylla*, and *Artemisia frigida* on unglaciated bedrock in the Southwestern Slope region.

Discussion

Physiographic Regions

Grasslands in the four physiographic regions of North Dakota range in type from subhumid tallgrass prairie in the Agassiz Lake Plain to semiarid plains in the Southwestern Slope dominated by short and midgrasses. The total bird density in particular areas of the North Dakota grasslands can be attributed largely

TABLE 5. Mean % cover of the ten most abundant plant species in eight major physiographic landforms within three physiographic regions of North Dakota, 1974.

	Southwestern Slope Region			Missouri Coteau Region		Drift Plain Region		
	Glacial outwash deposits	Sheet moraine	Unglaciated bedrock	Dead-ice moraine	Terminal moraine	Ground moraine	Lake plain	Terminal moraine
Species No. of plots →	(11)	(10)	(17)	(16)	(12)	(19)	(14)	(12)
Selaginella densa	7			7	7			
Psoralea argophylla		6	5					
Plantago patagonica			12					
Symphoricarpos occidentalis	4			16	16	14	7	27
Antennaria rosea							5	
Artemisia frigida		6	7				5	6
Carex eleocharis	16	12		6	19	6		8
Carex filifolia	10	12	17	10	6			
Carex pensylvanica	8	9		8	7	6		20
Agropyron caninum							7	
Agropyron smithii	9	11	22	10	7	10		8
Andropogon scoparius						5	5	
Bouteloua gracilis	17	23	21	15	13	22	25	34
Buchloe dactyloides			5					
Festuca octoflora			9					
Koeleria pyramidata	25	21	22	10	12	12	7	6
Poa pratensis	21			32	40	49	54	54
Stipa comata	17	21	16	12	10	4	6	5
Stipa viridula		12			5	5	6	5

to a few species (Table 2). The Missouri Coteau and Drift Plain not only supported 10–29% greater total bird density than the other regions but also a 3–15% greater species richness. The increased bird density in these two regions is due to their moderate attractiveness to species that reach greater densities, either in more arid areas to the west or in moister grasslands to the east, combined with markedly higher populations of a few characteristic species. Increased species richness in the two regions may be related to the abundance there of natural basin wetlands (the "Prairie Pothole Region" of waterfowl ecologists; Stewart and Kantrud 1971, 1973). The undulating topography is ecologically heterogeneous and soils bordering the wetlands generally support growths of taller grasses. Patches of mesic mixed-grass prairie occur adjacent to the tallgrass prairie and shorter, xeric mixed-grass prairie occurs nearby but at higher elevations. Each of these grassland types may be large enough to attract their characteristic bird species within a few hectares, thus increasing species richness. Although Wiens (1974) found relatively uniform densities of breeding birds among five types of North American grasslands, representing a much larger range of environmental conditions than occur among North Dakota grasslands, plot-to-plot and regional variations in grazing intensity may have obscured regional differences that may have existed.

There are indications that the number of bird species may also be increased in the Missouri Coteau and Drift Plain because the grasslands are predominately of intermediate height compared to the other two regions. Cody (1968, 1974) concluded that, while the shortgrass prairie was divided on the basis of foraging behavior and the tallgrass prairie according to vertical foraging range, in grasslands of intermediate height (about 0.75 m) the avifauna coexists by subdividing the habitat itself into patches of different height that are species-specific, further enhancing species richness.

Of 11 passerines found throughout North Dakota, three of the four largest in body size (Bobolink, Western Meadowlark, Red-winged Blackbird) occurred in highest density in the Agassiz Lake Plain, the region of greatest annual precipitation (Table 1). This tends to corroborate Wiens' (1974) suggestion that the standing crop biomass of passerine species may decrease across a gradient from subhumid tallgrass prairie to arid shrubsteppe.

On the Agassiz Lake Plain only 19 species were recorded compared to 22–28 for the other regions. The lower number is probably due in part to habitat

destruction by agricultural cultivation: Ferruginous Hawk, Sharp-tailed Grouse, Burrowing Owl, Long-billed Curlew, and Sprague's Pipit have been extirpated, or now survive only in very low numbers, in the Agassiz Lake Plain.

Physiographic Landforms

Grasslands developed over landforms lacking extensive soil development (sheet moraine, unglaciated bedrock) and those on coarse, nutrient-poor glacial deposits (kames, eolian sand) supported relatively low concentrations of birds and few species. Increased density and species richness was found on flatter landforms (outwash deposits, lake plain), landforms with the most fertile glacial soils (ground moraine, lake plain), and landforms with a greater variety of habitats (dead-ice moraine, ground moraine).

Differential use of landforms by individual species may be caused by a variety of factors. The higher densities of Baird's Sparrow and Chestnut-collared Longspur, in the Southwestern Slope region, on grasslands developed on outwash deposits, may be due to the flat topography characteristic of that landform. Flat topography has been noted as favorable for those species by Thompson (1890), Bird (1930), and Rand (1948). Terminal moraine, which is hillier than dead-ice moraine and contains fewer wetlands, supported a more dispersed, species-poor avifauna in the Missouri Coteau. Grasshopper Sparrow (Taverner 1927), Baird's Sparrow (Thompson 1890), and Chestnut-collared Longspur may have been more attracted to dead-ice moraine because of its more gentle relief. On the other hand, brush is more common on terminal moraines which explained their importance to such species as Common Yellowthroat, Vesper Sparrow, and Clay-colored Sparrow.

In the Drift Plain, the flat, moist lake plain was attractive to Marbled Godwit, Wilson's Phalarope, Sprague's Pipit, and Red-winged Blackbird. Ground moraine (which occupies intermediate elevations) supported higher populations of mixed-grass prairie species, including Grasshopper and Baird's Sparrows. The high, arid terminal moraines had higher densities of Horned Lark. Terminal moraines also often support well-developed stands of *Symphoricarpos occidentalis* which are highly attractive to Clay-colored Sparrow.

Land-Use

Grazing

During this study, mean total bird density was highest on heavily grazed plots, intermediate on moderately grazed, and lowest on lightly grazed. Heavy grazing resulted in reduced species richness, and increased dominance by a few species. The response of breeding birds to grazing (and other land-use practices) in mixed-grass prairies has been previously studied in two areas of North Dakota, Billings County (Hopkins 1980) and Stutsman County (Johnson 1972-1974), and also at Cottonwood, South Dakota (Wiens 1973); Nebraska Sandhills (Wiens and Dyer 1975); Matador, Saskatchewan (Maher 1973); and two sites in Alberta (Owens and Myres 1973; Karasiuk et al. 1977). Total bird density was always higher on idle or lightly grazed sites, except on the Saskatchewan area, which is in contrast to what is reported in this paper and so deserves discussion.

(i) Horned Lark and Chestnut-collared Longspur

During this study, over 60% of the total bird density on heavily grazed areas was attributable to the Horned Lark and Chestnut-collared Longspur. During the Saskatchewan study, the Horned Lark and the longspurs comprised over 85% of the bird population on grazed plots. A similar situation apparently exists in Manitoba where Harris (1944) stated that all but one of the Chestnut-collared Longspur nests were poorly concealed in cover thinned by cattle and grasshoppers. In Saskatchewan, Belcher (1961) and Roy (1964) also noticed the affinity of this species for overgrazed pastures. However, in Alberta, Owens and Myres (1973) and Smith (1976) stated that the semicolonial nature of the Chestnut-collared Longspur there results in great local variation in numbers.

The effects of grazing on rangeland avifaunas may apparently vary markedly in different western grassland types (Wiens and Dyer 1975). For example, on the shortgrass prairie of Colorado, Giezentanner (1970) found only small differences in density of Horned Lark among lightly, moderately, and heavily summer-grazed plots and the Chestnut-collared Longspur was absent under heavy grazing in that area. Bailey and Niedrach (1938) noted that Chestnut-collared Longspur were restricted to valleys in Colorado. In Montana, DuBois (1935) observed that this species nested in lower, moister areas than the Horned Lark.

(ii) Clay-colored Sparrow, Grasshopper Sparrow, and Baird's Sparrow

For these species, the negative response to heavy grazing, noted during this study, agrees with the results of the previous seven Canadian and American studies of the effects of grazing on the avifauna of mixed-grass prairie. Our findings also agree with those of Walkinshaw (1940) for the Grasshopper Sparrow and of Todd (1947) and Lane (1968) for the Baird's Sparrow.

(iii) Sprague's Pipit

Our findings on the effects of grazing on Sprague's

Pipit are in disagreement with the results of the three Canadian studies: Maher (1973) and Owens and Myres (1973) found much higher use of idle than of grazed plots by this species, and Karasiuk et al. (1977) found much greater numbers on lightly than on heavily grazed grasslands. In contrast, moderately and heavily grazed areas received greater use by Sprague's Pipit in North Dakota. This finding may again reflect (as in the cases of the Horned Lark and Chestnut-collared Longspur) the variable effects of grazing on a bird species in various grassland types. In Montana, Saunders (1914) also noted that the Sprague's Pipit commonly occurred in areas of sparse grass.

(iv) Western Meadowlark

In North Dakota, the Western Meadowlark was about equally common under the three levels of grazing intensity. Johnson (1972-1974) and Hopkins (1980) also found that grazing had negligible effects on this species in North Dakota. In both Alberta studies, it was about equally common under idle or grazed conditions. In the Nebraska Sandhills, it was a dominant species on grazed but not ungrazed prairie. In the South Dakota and Saskatchewan studies the Western Meadlowlark apparently preferred less heavily grazed areas. In Oklahoma, Smith (1940) found that only severe overgrazing made conditions unsuitable for it. In Montana, Thompson and Dahmer (1978) noted that severe grazing caused the species to abandon territories early in the breeding season.

(v) Upland Sandpiper

Upland Sandpiper showed little response to grazing pressure during this study, and that of Johnson (1972-1974), in North Dakota. It has been shown that, in Wisconsin and North Dakota, Upland Sandpiper prefer dense vegetative cover for nest sites (Ailes 1976; Higgins et al. 1969) and that grazing can be detrimental (Buss and Hawkins 1939; Kirsch and Higgins 1976). In one South Dakota study it occurred only in ungrazed plots (Wiens 1973), but in another (Lokemoen and Duebbert 1974) a very high nesting population occurred under moderate grazing. Upland Sandpiper may feed and rear their broods in very different habitats from that which they prefer for nest sites (Ailes 1976).

(vi) Lark Bunting

Lark Bunting showed a fairly strong affinity for moderately grazed areas during this study. Hopkins (1980) found small numbers only under moderate grazing in the North Dakota mixed-grass prairie while Johnson (1972-1974) recorded the species only under heavy grazing. On shortgrass prairie in the west, Lark Bunting is rare or absent under heavy summer grazing (Rand 1948; Finzel 1964; Giezentanner 1970).

(vii) Bobolink and Savannah Sparrow

In this study, these two species were greatly reduced or extirpated by heavy grazing. Johnson (1972-1974) found highest densities of Bobolink under lightly grazed conditions in North Dakota grasslands. Other studies of Bobolink (Kendeigh 1941; Tester and Marshall 1961; Hibbard 1965, 1972; Cody 1968; Wiens 1969; Martin 1971; Potter 1972; Harrison 1974) indicate a strong preference for tall, dense vegetation.

Johnson (1972-1974) found Savannah Sparrow about equally common under lightly and heavily grazed conditions in North Dakota grasslands but only small numbers of birds were observed. A preference for idle or lightly grazed areas was noted by Lincoln (1925), Rand (1948), Owens and Myres (1973), Karasiuk et al. (1977), and Maher (1979). This species shows an affinity for areas possessing dense ground cover (Tester and Marshall 1961; Lein 1968; Wiens 1969; Potter 1972).

(viii) Other Species

Short-billed Marsh Wren, Common Yellowthroat, Red-winged Blackbird, and LeConte's Sparrow were greatly reduced or extirpated by heavy grazing. Johnson (1972-1974) found highest densities of Common Yellowthroat under ungrazed conditions in North Dakota.

Mowing

Comparisons of data for plots of hayland with those from past studies are complicated by a number of factors. During this study, haylands censused had been mowed and raked the previous year, but not during the year of census. Thus by late spring they had grown appreciably, and attained many of the aspects of idle grassland without a well developed litter layer. This condition was characterized by dense populations of species which prefer taller grass for nesting cover: these included Bobolink, Red-winged Blackbird, Savannah Sparrow, and LeConte's Sparrow.

Two plots studied by Owens and Myres (1973) in Alberta also had been mown and raked the previous year, but by mid-June of the year of census they contained vegetation only 20–30 cm tall; in this case the avian community was dominated by Sprague's Pipit and Chestnut-collared Longspur, two species which in North Dakota grasslands showed favorable response to short vegetation created by moderate or heavy grazing.

Though nowhere common, LeConte's Sparrow reached peak numbers on hayland during this study, whereas Murray (1969), also in North Dakota, noted the importance of litter for breeding of this species and believed annual mowing would extirpate it. This disparity may be related not only to the time of harvest but also to differences in forage-harvesting tech-

niques. Thus, removal of grassland vegetation has been shown to have different effects on important characteristics of the vegetation such as height, density, and amount of litter (Owens and Myres 1973; Weaver and Fitzpatrick 1934; Wiens 1973), and several studies (Tester and Marshall 1961; Wiens 1969) have shown that changes in litter appear to cause changes in distribution and abundance of Bobolink, Savannah Sparrow, and LeConte's Sparrow.

Bobolink peak densities occurred on hayland in this investigation and those of Bailey (1915), Kendeigh (1941), and Springer (1965). Hibbard (1972) attributed lower numbers of this species on burned tallgrass prairie to lack of a litter layer. Martin (1971) reported that Bobolink males which attracted the most females inhabited fields with increased vegetation density and horizontal heterogeneity, but male pairing levels were not correlated with litter depth. Without detailed experimental studies it is difficult to determine which vegetational factors these populations were responding to, because Penfound (1964) has shown that denudation of the litter layer in tallgrass prairie through mowing ultimately results in increased vegetative biomass, productivity, and number of species.

In conclusion, the results of this study indicate that the distribution and abundance of most grassland bird species in North Dakota have been negatively affected by agricultural and pastoral activities. Grassland plots on the flatter, more fertile landforms were difficult to find, especially in the intensively-cultivated Agassiz Lake Plain region. This region supported highest measured densities of most species found there, but was also the region in which the fewest species were recorded, indicating that fragmentation of grasslands by agriculture has not only resulted in extirpation of species originally present but that, acre-for-acre, cultivation of eastern tallgrass prairie has destroyed better habitat for more bird species than in the shorter grasslands to the west. Abuse of native grasslands by overgrazing has also had a negative impact as evidenced by the small number of species that reached highest densities and the reduced species richness under heavy grazing.

I recommend that protection be given to larger remaining areas of unplowed grassland representative of the various types found throughout the state. Grazing and burning management should then be applied in order to promote the continued survival of the native grassland birds that are now much less common than formerly.

Acknowledgments

R. E. Stewart supervised this investigation and participated in the field work. Assistance in the field was received from L. M. Cowardin, D. S. Gilmer, A. T. Klett, and J. T. Lokemoen. I thank D. Alan Davenport and D. H. Johnson for their help with computer programming and C. A. Faanes and J. R. Serie for reviewing earlier drafts of the manuscript. The study was supported by the U.S. Fish and Wildlife Service through the Migratory Birds Program and the Coal Project, Western Energy Land Use Team, Office of Biological Services.

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Received 5 May 1980
Accepted 28 March 1981

APPENDIX A. Descriptions of 13 physiographic landforms on which sample sites were located in North Dakota.

Landform	Description
Alluvial River Deposits	Generally flat topography underlain by glacial sediments deposited by modern rivers on valley floors.
Dead-ice Moraine	Hilly areas where large amounts of rock and sediment, incorporated into and on top of advancing glaciers, slumped and slid as the glaciers stagnated and melted. Dead-ice moraine contains large numbers of both deep and shallow wetlands.
Deltaic Deposits	Flat or gently undulating sandy or silty areas formed where large rivers flowed into glacial lakes.
Eolian Sand	The wind-worked surfaces of sandy areas such as glacial river deltas or outwash plains. Topography is generally of choppy dunes with a few shallow wetlands.
Glacial Outwash Deposits	Broad, flat plains of sand and gravel deposited by water flowing from melting glaciers. Saline wetlands are common in many outwash areas. In some areas, outwash was deposited over stagnant ice which resulted in more rugged topography and numerous, less saline wetlands.
Glaciated Bedrock	Various types of sedimentary bedrock (shales, sandstones, siltstones, etc.). Glaciated but glacial remnants usually restricted to a few scattered boulders. These sediments are well drained due to post-glacial erosion.
Ground Moraine	Gently rolling topography covered with moderate amounts of glacial till. This is the most common glacial landform in North Dakota and is characterized by fertile soils and numerous shallow basin wetlands.
Kames	Mounds and conical hills of gravel, sand, silt, and clay which were formed when depressions in glaciers filled with these materials slumped during the glacial melt period.
Lake Plain	Flat deposits of sediment which formed the bottoms of lakes created by glacial blockage of major drainageways. The most fertile agricultural soils in North Dakota occur in lake plains (Patterson et al. 1968).
Lake Shore Deposits	Gently undulating sand and gravel beaches or wave-cut scarps of other material formed at the edges of glacial lakes.
Sheet Moraine	Areas occupying the outer limits of glaciation which contain a continuous or patchy thin layer of glacial till.
Terminal Moraine	Hilly, thick deposits of glacial till formed at the edges of glaciers. Terminal moraine commonly occur as areas a few km wide and several tens of km long and contain moderate numbers of small, shallow wetlands.
Unglaciated Bedrock	Bedrock of various types lying south and west of the furthest advance of Wisconsin age glaciation. Gently undulating grasslands on this type usually have developed on a single parent material but several parent materials may be represented over large areas. Well drained due to erosion with few natural basin wetlands.

Relative Abundances of Birds in Boreal and Subarctic Habitats of Northwestern Ontario and Northeastern Manitoba

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McLaren, Margaret A. and Peter L. McLaren. 1981. Relative abundances of birds in boreal and subarctic habitats of northwestern Ontario and northeastern Manitoba. Canadian Field-Naturalist 95(4): 418–427.

Indices of abundance of breeding birds based on transect surveys are presented for an area stretching 1 000 km NW from the Albany River, Ontario to the Caribou River, Manitoba. Data are summarized for six geographic areas and nine habitats. Overall abundance changed little with latitude. Species composition changed considerably and these changes are discussed in relation to habitat. The highest abundance indices of birds were found in deciduous scrub and the lowest in coniferous forest with no understory.

Key Words: Breeding birds, relative abundance, boreal forest, subarctic, Ontario, Manitoba.

The avifauna of the interior of northwestern Ontario and northeastern Manitoba is poorly known. James et al. (1976) summarized the known distributions of birds in Ontario and made qualitative assessments of abundance. Their data base was very small for interior areas north of 51° N and consisted primarily of records from visits to Favourable Lake in 1938 (Royal Ontario Museum records) and Big Trout Lake in 1975 (Lee 1978). The interior of northeastern Manitoba is similarly poorly known although one quantitative study has been done there (Gillespie 1960).

In this paper we present indices of abundances (expressed as birds/km^2) of breeding birds in terrestrial habitats along a proposed pipeline corridor in an area reaching from the Albany River, Ontario, northwest 1000 km to the Caribou River, Manitoba. Supplementary information about limits of distribution and nesting has been presented in McLaren and Renaud (1980) and McLaren and McLaren (1981).

Methods

We conducted line transect surveys at 55 sites from 3-27 June 1977 (Figure 1). Sites within 75 km of Pickle Lake, Ontario and at Gillam, Manitoba, were reached by car; all others were reached by helicopter. Sites were distributed along the pipeline corridor; logistic considerations with the helicopter (possible landing sites, cruising range) precluded regularly spaced sampling. About 2.6 km (range: 1 280-4 570 m) of transect were surveyed at each site and all but 2 sites were surveyed between 04:40 and 10:00. Transects normally followed the form of a square or three sides of a rectangle. 'Edge effects' were avoided by starting and finishing transects at least 50 m from a road, lake or river.

We conducted line transect surveys, rather than plot surveys, because of the necessity of sampling a large area (ca. 1 000 km in length) in a single season. The method used was a variant of those described by Graber and Graber (1963) and by Emlen (1971,1977). At each site two observers walked parallel courses 20 m apart; one recorded the birds detected while the other recorded habitat information. Bird data included the species, number detected, estimated distance of the bird from the centre-line of the transect, vocalizations (if any) and when possible, behaviour, age, and sex of the bird(s) detected. All birds detected, regardless of their lateral distances, were recorded. The second observer used a hand-held counter to tally the number of paces covered and recorded habitat type and variables every 200 paces. This observer also noted the pace number where the habitat type changed. A factor converting paces to metres was determined for each 'habitat recorder' and applied to the pace data. The fact that we could regularly circumnavigate a square by compass, returning to within about 50 m of the starting point, suggests that pacing was consistent.

Only birds estimated to be within 50 m of the centre-line of the transect strip were used in the calculation of indices. Records of flocks of five or more birds and records of birds flying over the transect strip from a location off-transect but not landing on the transect were not included in calculations.

The index of abundance was calculated as the number of birds per square kilometre. This represents only minimum densities of birds present in an area or habitat. Absolute densities cannot be determined from single replicate transect surveys since not all birds will be detected. Methods to estimate absolute densities using correction factors determined from replicate transects have been developed (Emlen 1977; Jarvinen and Väisänen 1976; Järvinen et al. 1976, 1977). However, the scope of our study did not permit us to replicate transects and thus determine correction

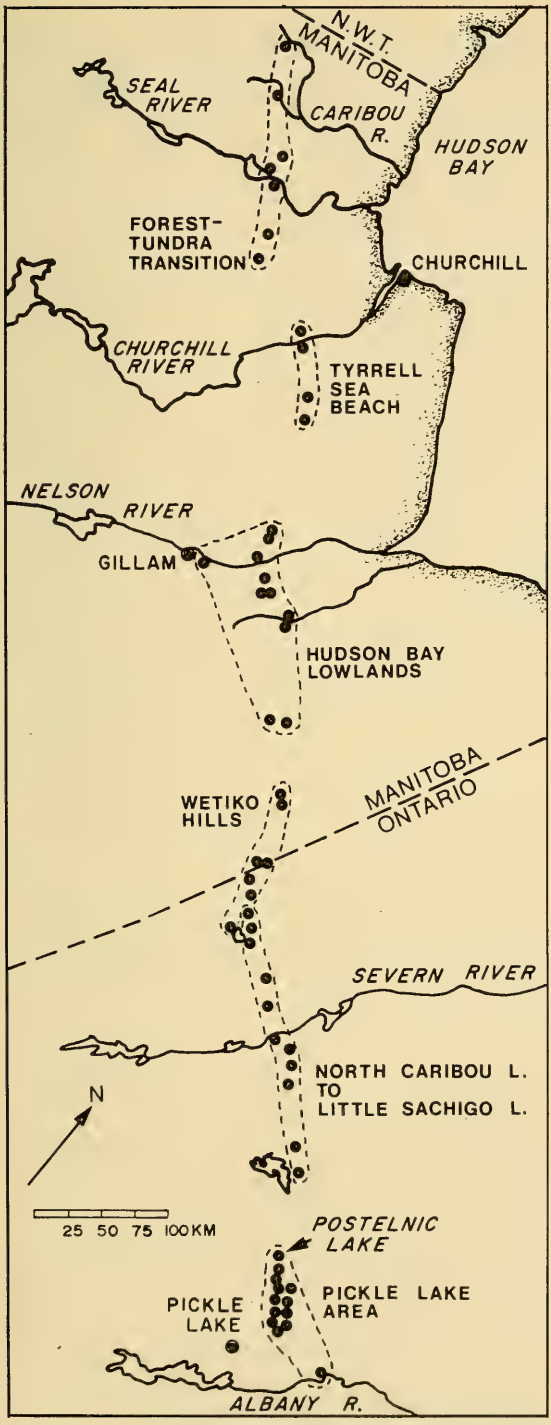

FIGURE 1. Sites surveyed in northwestern Ontario and northeastern Manitoba.

factors. Because we recorded all birds detected, we express our results as 'birds/km²' rather than as 'males/km²'. Nevertheless, the large majority of passerines were identified as males (80%) and the indices for most passerines represent pairs detected per km².

Factors affecting detection of birds include weather conditions, time of day, rate of progress, observer ability and, especially, conspicuousness of the bird species. Most of our surveys were conducted in the early morning and under similar weather conditions. We attempted to keep our rate of progress constant although transects with large numbers of birds were slower (because recording took longer) than transects with fewer birds. In addition, progress was probably slower in dense habitats (e.g. deciduous scrub) than in open habitats, even though we deliberately walked slowly in the latter. Conspicuous birds, in this study, are those that vocalize frequently and loudly. Since the majority of birds recorded were heard but not seen, even among the quiet species, the 'openness' of the habitat should not have affected detection rate greatly. Because detection rate is unknown but undoubtedly differs among species we do not compare the relative indices of abundance among or between species but only among geographic areas or among habitats for individual species or all birds combined. Similarly, because the indices presented are not exact and represent only minimum densities we consider only relatively large differences to be real.

The 55 sites where surveys were conducted were grouped into six geographic regions (Figure 1). These regions were chosen partly on the basis of geographic proximity and partly on the basis of similarity of habitats at the sites within each group (Figure 2). All sites were within the boreal forest region (Rowe 1972); the three southern groupings were in predominantly continuous forest, whereas the northern three were in a zone of forest interspersed with barrens, although most sites sampled on the Tyrrell Sea Beach were in forest.

Habitat Descriptions

The work presented here was part of a study of bird populations in a much larger area stretching from the Canadian high arctic to central Ontario. Because of the wide latitudinal range in the larger study area, habitat classification was based on the very general scheme of Fosberg (1967). The primary characteristic in that scheme is the degree of openness of the canopy plants. Secondary and tertiary characteristics are height of woody vegetation (forest, > 5 m; scrub, 0.5 m-5 m; heath, < 0.5 m; and tundra) and physiognomy (needle-leaved vs. broad-leaved plants). Because intrusions of physiognomically different plants can affect bird communities (Erskine 1977), we also recognized a 'mixed' category defined as having

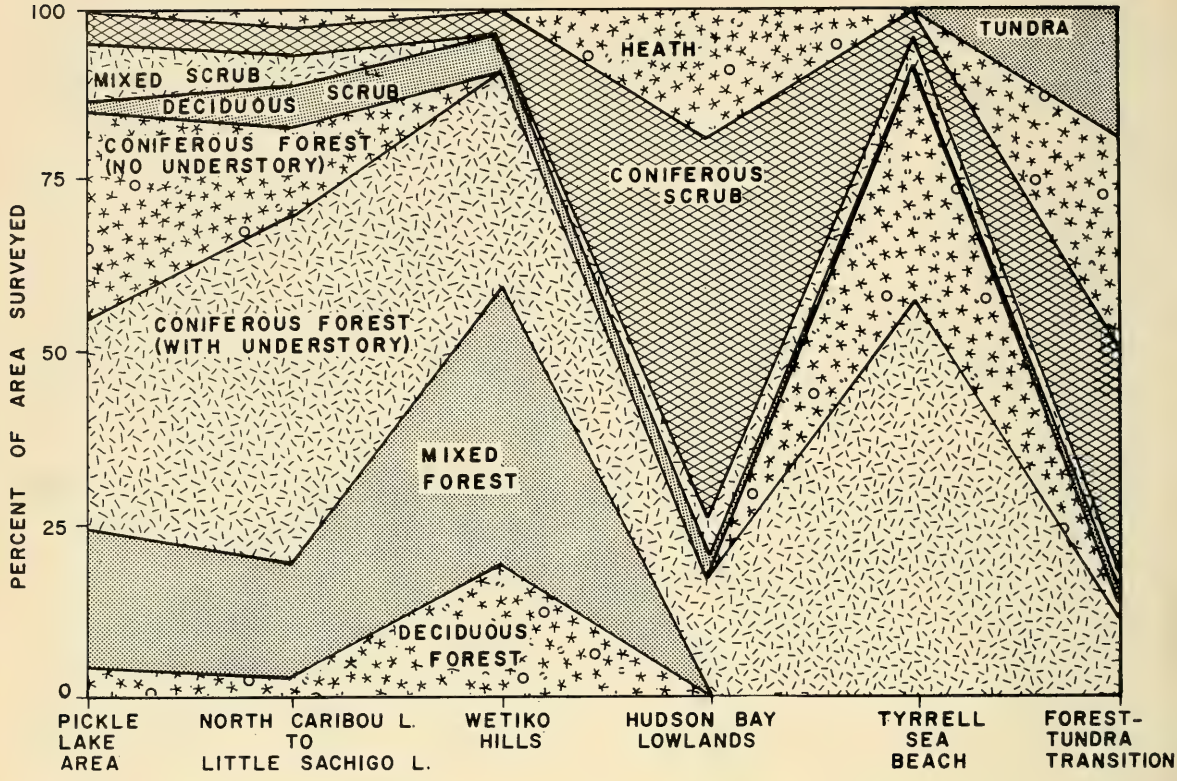

FIGURE 2. Distribution of habitats in northwestern Ontario and northeastern Manitoba based on habitat sampling during transects.

ratios of 30:70 to 70:30 deciduous to coniferous vegetation in the canopy. In order to increase the sample size in individual habitats we combined closed and open canopy categories for each height and physiognomy grouping. Within any region, a given habitat was usually either closed or open, so this combination is not seen as contrary to the classification scheme.

We identified 9 general habitats that comprised 99% of the area surveyed. Deciduous forest occurred in the southern three regions (Figure 2) and was characterized by Trembling Aspen (*Populus tremuloides*) with occasional White Birch (*Betula papyrifera*). Coniferous forests occurred in all six regions and were primarily Black Spruce (*Picea mariana*). Coniferous forests with understory averaged 45% understory cover and without understory averaged 15% cover. Understory, when present, was about equally divided between coniferous (young coniferous trees) and deciduous [Alder (*Alnus* spp.) and willow (*Salix* spp.)] vegetation. Coniferous forest with understory was generally an open canopy forest; all other forest habitats were closed canopy except for coniferous (lichen) forest on the Tyrrell Sea Beach.

Coniferous scrub was composed primarily of Black Spruce and occasionally (north to the Wetiko Hills) Jack Pine (*Pinus banksiana*). Deciduous scrub was mainly alder and willow but occasionally Dwarf Birch (*B. glandulosa*). Both mixed forest and mixed scrub were composed of the same species as the respective pure deciduous or coniferous habitats.

Typical plants in heath were Labrador Tea (*Ledum groenlandicum*), *Ledum decumbens,* Leatherleaf (*Chamaedaphne calyculata*), blueberry (*Vaccinium* spp.) and Dwarf Birch. In the northern part of the study area heath tended to be open with a ground cover of grasses (Gramineae) or sedges (Cyperaceae) whereas farther south there was little gramineous vegetation. Tundra occurred only in the extreme north of the study area and was dominated by dwarf shrubs such as Crowberry (*Empetrum nigrum*) and Alpine Azalea (*Loiseleuria procumbens*), by sedges, or by a combination of dwarf shrubs and sedges.

A dominant feature of the boreal forest is the presence of muskeg. Muskeg supports a variety of vegetation types ranging from sedge to spruce forest but all are characterized by the presence of organic soils

(Radforth 1969). Although we did not distinguish muskeg habitat from similar habitats on mineral soils, many of our survey sites, especially in the North Caribou to Little Sachigo Lake area, the Hudson Bay Lowlands and the Forest-Tundra Transition, were in muskeg.

Mixed and deciduous forest occurred only from the Albany River to the Wetiko Hills. Mixed and deciduous scrub habitats were encountered more frequently in the three southern areas than in the north. Scrub habitats (including coniferous scrub) in these southerly areas tended to consist of young regeneration (after fire) rather than stunted forest which dominates the northwestern Hudson Bay Lowlands (Rowe 1972). Coniferous forest with understory was a relatively common habitat throughout the study area. On the Wetiko Hills, the Tyrrell Sea Beach and, to a lesser extent, in the Pickle Lake area, coniferous forest with understory tended to occur on well drained uplands whereas in the other three areas it tended to be on muskeg. Coniferous forest without understory was encountered only in the two southern areas, where the ground cover was usually moss, and on the Tyrrell Sea Beach, where ground cover for all habitats was lichen.

Heath occured primarily in the Hudson Bay Lowlands, where it was encountered in about equal proportions of open muskeg and regeneration after fire on mineral soil, and in the Forest-Tundra Transition. Heath and tundra together comprised almost half (Table 1) of the habitat surveyed in this area.

Very small amounts of three other habitats occurred on the transect strips — grassy marsh, lake and recently burned forest with little or no living vegetation.

Spruce Budworm (*Choristoneura fumiferana*), which may markedly affect densities of birds in the boreal forest (Kendeigh 1947; Erskine 1977), was not conspicuously abundant at any of the sites surveyed.

Results

Lowest abundance indices were recorded in coniferous forest without understory and heath (Table 1). All of the high densities, in deciduous forest, deciduous scrub and mixed scrub, were based on very small samples. There was considerable variation in these indices within one habitat type among different areas. For example, the abundance index in coniferous forest with understory in the Wetiko Hills was much higher than in any other region. Similarly, the abundance index for mixed scrub in the Hudson Bay Lowlands, based on a very small sample, was much higher than the other values for this habitat (Table 1).

Table 2 presents abundance indices of all species that were recorded during the surveys. Many species, particularly some of the non-passerines, were detected very rarely, and their occurrence in a given habitat should not be interpreted as a preference for that habitat. It is readily apparent from the table that none of the more common species was restricted to only one of even the very general habitat types considered, and that many species occur in four or more different habitat types.

Nevertheless, each habitat did support a generally distinct combination of bird species. The species most representative of deciduous forest (i.e. highest abundance indices) were the Least Flycatcher, Red-eyed Vireo and Ovenbird, although Ruffed Grouse and Yellow-bellied Sapsuckers were also typical. The species most representative of spruce forest with or without understory, were the Gray Jay, Ruby-crowned Kinglet and Yellow-rumped Warbler. The Golden-crowned Kinglet was more abundant in mixed forest than in spruce forests but was, nevertheless, found only in habitats containing spruce trees. The Blackpoll Warbler was the most abundant species in spruce scrub but the Palm Warbler, Rusty Blackbird, Dark-eyed Junco and, to a lesser extent, Lincoln's Sparrow, were also common. In deciduous scrub, Tennessee and Wilson's warblers and White-throated and White-crowned sparrows were the most abundant species. Swainson's Thrush was found in all forest and scrub habitats but was considerably more abundant in deciduous scrub than in the others.

The Lapland Longspur was the dominant species in both heath and tundra. Other common tundra species included the Horned Lark, Common Redpoll and Savannah Sparrow. Common heath species included the Tennessee Warbler, Blackpoll Warbler, Rusty Blackbird, Savannah Sparrow, Dark-eyed Junco and Tree Sparrow. No species was more abundant in heath than in any other habitat.

Concomitant with changes in vegetation, the composition of the avian community changed with increasing latitude. Figure 3 summarizes the changes in species composition and shows graphically the gradual disappearance of species associated with deciduous and mixed forests (e.g., Red-eyed Vireo, Nashville Warbler, Ovenbird) and the appearance, first of species of low coniferous forests (e.g., White-crowned Sparrow, Tree Sparrow) and then of species of treeline and tundra (e.g., Harris' Sparrow, Lapland Longspur). Interestingly, although the abundance of most species varied considerably over the study area, the overall density of birds remained quite similar over a north-south distance of approximately 1 000 km (Table 2).

Discussion

The indices reported here are not directly comparable with most previous quantitative studies of bird populations in the boreal forest (e.g., Ward 1975; Erskine 1977) because of differences in survey method

TABLE 1. Overall indices of abundance (birds/km²) (boldface) in six areas and nine habitats in northwestern Ontario and northeastern Manitoba. (PL = Pickle Lake, NCLS = North Caribou Lake to Little Sachigo Lake, WH = Wetiko Hills, HBL = Hudson Bay Lowlands, TSB = Tyrrell Sea Beach, FTT = Forest-Tundra Transition, see Figure 1; DF = Deciduous Forest, CFU = Coniferous Forest with Understory, CF = Coniferous Forest without Understory, MF = Mixed Forest, DS = Deciduous Scrub, CS = Coniferous Scub, MS = Mixed Scrub, He = Heath, Tu = Tundra. Indices were not calculated for surveys of < 1 km; '+' indicates that birds were present. Numbers in parentheses are km surveyed.

	DF	CFU	CF	MF	DS	CS	MS	He	Tu	OVERALL[1]
PL	**214** (1.5)	**106** (10.5)	**77** (10.6)	**163** (6.5)	+ (0.6)	**95** (1.3)	**202** (3.1)	+ (0.2)	—	**126** (34.6)
NCLS	+ (< 0.1)	**128** (16.3)	**83** (5.7)	**141** (2.7)	**218** (1.7)	+ (1.0)	**140** (1.7)	**90** (1.0)	—	**124** (30.9)
WH	**141** (3.3)	**241** (5.4)	+ (0.1)	**129** (6.6)	+ (0.8)	+ (0.5)	+ (< 0.1)	+ (< 0.1)	—	**187** (16.7)
HBL	+ (< 0.1)	**158** (4.6)	—	—	+ (0.8)	**156** (14.7)	**419** (1.4)	**131** (4.7)	—	**181** (26.4)
TSB	—	**137** (6.7)	**118** (3.8)	+ (< 0.1)	+ (0.4)	+ (0.6)	—	—	—	**124** (11.5)
FTT	—	**209** (3.1)	+ (0.3)	—	+ (0.1)	**146** (8.0)	+ (0.6)	**98** (7.4)	**130** (3.8)	**130** (23.6)
OVER-ALL	**190** (4.9)	**145** (46.5)	**86** (20.6)	**146** (15.9)	**373** (4.4)	**147** (26.0)	**220** (6.9)	**104** (13.4)	**130** (3.8)	

[1]Distances do not always add up to the total because of the presence of small amounts of other habitats (see text).

Table 2. Indices of abundance of birds (birds/km²) in six areas and nine habitats in northwestern Ontario and northeastern Manitoba. Area and habitat designations are as in Table 1. '+' indicates species present but not recorded on the transect strip. Numbers in parentheses are either the number of sites or the number of sites at which the habitat type was recorded.

	Area						Habitat								
Species	PL (14)	NCLS (12)	WH (7)	HBL (11)	TSB (4)	FTT (7)	DF (11)	CFU (45)	CF (21)	MF (23)	DS (12)	CS (32)	MS (15)	He (19)	Tu (3)
American Bittern *Botaurus lentiginosus*	—	1	+	—	—	—	—	<1	—	—	—	—	1	—	—
Canada Goose Branta canadensis	—	+	—	+	—	1	—	—	—	—	—	1	—	—	—
Mallard *Anas platyrhynchos*	+	+	+	<1	—	—	—	—	—	—	—	—	—	—	—
Green-winged Teal *Anas crecca*	—	—	1	—	—	—	—	<1	—	—	—	—	—	—	—
Blue-winged Teal *Anas discors*	—	<1	—	1	—	—	—	1	—	—	—	—	—	—	—
American Kestrel *Falco sparverius*	—	+	+	—	1	—	—	+	<1	+	—	—	—	—	—
Spruce Grouse *Canachites canadensis*	1	1	1	—	1	—	—	<1	1	3	—	—	1	—	—
Ruffed Grouse Bonasa umbellus	1	1	1	<1	—	—	6	<1	—	1	—	1	—	—	—
Common Snipe *Capella gallinago*	<1	1	+	2	+	<1	—	<1	<1	—	—	1	+	—	—
Whimbrel Numenius phaeopus	—	—	—	—	—	2	—	—	—	—	—	—	—	2	5
Solitary Sandpiper *Tringa solitaria*	—	+	+	2	+	1	—	<1	—	—	—	1	3	—	—
Greater Yellowlegs *Tringa melanoleuca*	+	<1	—	4	2	<1	—	<1	1	—	—	3	—	4	+
Lesser Yellowlegs Tringa flavipes	—	+	—	5	2	4	—	<1	1	—	—	5	1	4	5
Least Sandpiper *Calidris minutilla*	—	—	—	2	—	3	—	<1	—	—	—	—	—	2	21
Short-billed Dowitcher *Limnodromus griseus*	—	—	—	<1	—	1	—	—	—	—	—	2	—	2	—
Stilt Sandpiper *Micropalma himantopus*	—	—	—	—	—	1	—	—	—	—	—	—	—	2	—
Northern Phalarope *Lobipes lobatus*	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—
Bonaparte's Gull *Larus philadelphia*	+	—	—	+	—	1	—	—	—	—	—	1	—	1	—
Short-eared Owl *Asio flammeus*	—	—	—	—	1	+	—	—	1	—	—	—	—	—	—
Belted Kingfisher *Megaceryle alcyon*	+	—	+	+	1	—	—	<1	—	—	—	+	—	—	—
Common Flicker *Colaptes auratus*	+	—	1	+	1	—	—	1	—	+	—	—	—	—	—
Yellow-bellied Sapsucker *Sphyrapicus varius*	2	—	2	—	—	—	6	—	—	2	6	—	—	—	—
Black-backed Three-toed Woodpecker *Picoides arcticus*	—	1	1	<1	—	—	—	—	—	<1	—	—	—	1	—
Yellow-bellied Flycatcher *Empidonax flaviventris*	8	7	10	3	5	3	6	9	4	5	2	4	9	2	—
Alder Flycatcher r *Empidonax alnorum*	2	1	2	5	—	<1	2	1	—	+	—	1	9	—	—
Least Flycatcher *Empidonax minimus*	8	2	8	<1	—	—	28	2	3	2	6	1	10	—	—
Olive-sided Flycatcher *Nuttallornis borealis*	<1	1	+	+	—	—	—	<1	—	1	—	+	1	—	—
Horned Lark *Eremophila alpestris*	—	—	—	—	—	4	—	—	—	—	—	1	—	3	13
Tree Swallow *Iridoprocne bicolor*	1	+	—	1	—	—	—	1	<1	—	—	+	1	2	—
Gray Jay *Perisoreus canadensis*	3	11	6	5	13	2	—	12	5	3	—	5	7	—	—
Common Raven *Corvus corax*	+	+	<1	+	—	+	—	<1	+	+	—	—	—	—	—
Boreal Chickadee *Parus hudsonicus*	1	2	1	—	—	5	—	4	—	—	4	2	—	—	—
Red-breasted Nuthatch *Sitta canadensis*	1	+	+	+	+	1	—	+	—	1	—	1	—	—	—
Brown Creeper *Certhia familiaris*	3	1	1	—	—	—	—	2	<1	4	—	—	—	—	—
Winter Wren *Troglodytes trogloydtes*	1	+	—	+	—	—	—	—	<1	—	—	—	+	—	—
Hermit Thrush *Catharus guttatus*	1	1	1	1	1	+	—	1	—	<1	5	1	1	—	—
Swainson's Thrush *Catharus ustualtus*	8	8	5	<1	1	<1	10	5	4	9	14	<1	4	—	—
Gray-cheeked Thrush *Catharus minimus*	—	—	—	<1	1	5	—	1	—	—	+	2	3	2	—
Golden-crowned Kinglet *Regulus satrapa*	5	2	3	—	—	—	—	1	4	7	—	—	—	—	—

TABLE 2 (Continued)

Species	Area						Habitat								
	PL (14)	NCLS (12)	WH (7)	HBL (11)	TSB (4)	FTT (7)	DF (11)	CFU (45)	CF (21)	MF (23)	DS (12)	CS (32)	MS (15)	He (19)	Tu (3)
Ruby-crowned Kinglet *Regulus calendula*	9	8	7	1	8	2	+	10	6	5	7	<1	1	1	—
Waxwings *Bombycilla* spp.	1	—	—	1	+	—	6	+	1	—	—	—	—	—	—
Northern Shrike *Lanius ludovicianus*	—	—	—	1	—	<1	—	<1	—	—	—	<1	—	—	—
Solitary Vireo *Vireo solitarius*	1	1	1	—	—	—	4	—	1	3	—	<1	1	—	—
Red-eyed Vireo *Vireo olivaceous*	5	2	10	—	—	—	32	1	<1	11	9	+	3	—	—
Philadelphia Vireo *Vireo philadelphicus*	<1	—	—	—	—	—	2	—	—	—	—	—	—	—	—
Black-and-white Warbler *Mniotilta varia*	2	<1	5	<1	—	—	4	<1	—	1	11	—	12	—	—
Tennessee Warbler *Vermivora peregrina*	1	10	40	12	15	3	10	16	1	14	51	6	10	6	—
Orange-crowned Warbler *Vermivora celata*	<1	1	1	2	1	—	—	1	<1	—	5	2	1	—	—
Nashville Warbler *Vermivora ruficapilla*	5	1	4	—	—	—	+	2	3	1	7	—	4	—	—
Yellow Warbler *Dendroica petechia*	+	2	1	2	—	—	8	<1	—	<1	11	—	1	—	—
Magnolia Warbler *Dendroica magnolia*	5	3	7	1	—	—	4	3	<1	5	5	1	10	—	—
Yellow-rumped Warbler *Dendroica coronata*	5	10	6	2	10	3	—	10	10	4	7	1	—	2	—
Black-throated Green Warbler *Dendroica virens*	1	—	—	—	—	—	+	<1	—	1	—	—	—	—	—
Chestnut-sided Warbler *Dendroica pensylvanica*	<1	—	—	—	—	—	—	—	—	<1	2	—	—	—	—
Bay-breasted Warbler *Dendroica castanea*	3	1	7	—	—	—	4	1	2	8	—	—	—	—	—
Blackpoll Warbler *Dendroica striata*	+	4	10	26	7	18	—	12	2	2	16	25	13	5	5
Palm Warbler *Dendroica palmarum*	+	5	1	12	+	1	—	4	—	—	5	10	7	1	—
Ovenbird *Seiurus aurocapillus*	7	<1	8	—	—	—	24	1	1	16	+	+	—	—	—
Northern Waterthrush *Seiurus noveboracensis*	<1	1	2	4	—	<1	4	1	+	—	7	2	3	—	—
Connecticut Warbler *Oporornis agilis*	1	1	—	—	—	—	—	1	<1	—	—	1	—	—	—
Mourning Warbler *Oporornis philadelphia*	1	—	—	—	—	—	+	<1	+	—	—	—	1	—	—
Common Yellowthroat *Geothlypis trichas*	<1	—	—	—	—	—	—	—	—	—	2	—	+	—	—
Wilson's Warbler *Wilsonia pusilla*	2	4	1	4	1	—	2	1	<1	<1	35	1	16	—	—
Canada Warbler *Wilsonia canadensis*	<1	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Rusty Blackbird *Euphagus carolinus*	1	2	+	9	1	6	—	2	—	<1	5	10	7	6	—
Pine Grosbeak *Pinicola enucleator*	—	—	—	1	4	1	—	1	—	—	—	1	1	—	—
Common Redpoll *Carduelis flammea*	—	—	—	—	—	1	—	—	—	—	—	—	—	—	16
Pine Siskin *Carduelis pinus*	2	1	+	+	—	—	—	+	3	2	—	—	+	—	—
White-winged Crossbill *Loxia leucoptera*	—	—	—	+	15	4	—	3	5	—	—	1	—	—	3
Unidentified Crossbill *Loxia* sp.	1	1	+	1	—	—	—	3	<1	1	<1	<1	—	1	—
Savannah Sparrow *Passerculus sandwichensis*	+	1	—	2	—	3	—	—	—	+	—	<1	3	5	8
Dark-eyed Junco *Junco hyemalis*	3	5	7	8	10	6	2	7	4	2	—	8	10	5	—
Tree Sparrow *Spizella arborea*	—	<1	—	1	+	8	—	1	—	—	2	1	1	5	8
Chipping Sparrow *Spizella passerina*	2	7	1	3	2	1	—	4	3	<1	5	5	4	1	—
Harris' Sparrow *Zonotrichia querula*	—	—	—	—	—	5	—	<1	—	—	5	1	1	4	—
White-crowned Sparrow *Zonotrichia leucophrys*	—	—	—	18	4	2	—	2	+	—	28	11	10	2	+
White-throated Sparrow *Zonotrichia albicollis*	2	5	4	6	3	+	2	4	+	1	23	2	13	3	+
Fox Sparrow *Passerella iliaca*	1	<1	2	3	+	2	2	1	—	—	2	3	4	—	—

Table 2 (Concluded)

Species	Area						Habitat								
	PL (14)	NCLS (12)	WH (7)	HBL (11)	TSB (4)	FTT (7)	DF (11)	CFU (45)	CF (21)	MF (23)	DS (12)	CS (32)	MS (15)	He (19)	Tu (3)
Lincoln's Sparrow *Melospiza lincolnii*	+	1	1	12	3	1	—	2	<1	—	5	9	1	—	—
Song Sparrow *Melospiza melodia*	+	+	—	1	—	<1	—	—	—	—	5	<1	+	2	—
Lapland Longspur *Calcarius lapponicus*	—	—	—	—	—	20	—	—	—	—	2	2	—	24	40
Smith's Longspur *Calcarius pictus*	—	—	—	—	—	1	—	—	—	—	—	—	—	1	5
All passerines[1]	117	119	179	162	115	114	175	140	79	137	365	132	204	84	98
All birds[1]	126	124	187	181	124	130	190	145	86	146	373	147	220	104	130
% passerines	93	96	96	90	93	88	92	97	92	94	98	90	93	81	72

[1]The totals exceed the sums of the individual densities because records of unidentified birds are not included in the species list.

and in habitat classification. Densities derived from plot surveys (Erskine 1977) or narrow transects (Ward 1975) tend to be similar and higher than densities derived from wide transects (LGL Ltd. unpubl. data). The most nearly comparable data are those of James (1980) in the Pickle Lake area. Using one observer and a 50 m wide transect, he recorded an average index of 155 pairs/km^2, a value not greatly different from our results in the same area.

Although quantitative comparisons are not possible, a number of qualitative similarities between our results and those of other workers are evident. Gillespie (1960) and Carbyn (1971) both surveyed plots that correspond in habitat type to our coniferous forest without understory and both reported their lowest densities on these plots. We also found the fewest birds in this habitat. Considerable variation in the calculated densities in habitats corresponding to our coniferous forest with understory were also noted by other workers (Gillespie 1960; Carbyn 1971; Ward 1975). Reasons for such variation are not apparent, but may reflect, at least partly, both the amount and the type of undergrowth in the forest.

Most of our samples of deciduous scrub were very small and open to sampling error. Nevertheless, the very high relative density we found is similar to the pattern seen in other studies. Salter and Davis (1974), Tull et al. (1974), Ward (1975) and Wisely and Tull (1977) all surveyed several habitats in the Mackenzie Valley and found that relative densities were highest in scrub habitats with a deciduous component. Ward (1975) found, as we did, that in scrub habitats relative densities were highest in deciduous scrub, lowest in coniferous scrub and intermediate in mixed scrub. Gillespie (1960) also found very high densities in deciduous scrub along a stream near Churchill, Manitoba. He reported that densities in coniferous forest and scrub were only 28% to 39% of the density in deciduous scrub. Our results are remarkably similar; minimum densities in coniferous forest and scrub varied from 23% to 39% of those in deciduous scrub.

Few species of birds were confined to only one of the general habitats distinguished in this study. Several of the habitats included a common vegetational feature (e.g. coniferous trees) and it is possible that birds were responding to the presence of this single feature rather than to the broad habitat mosaic. On the other hand, some species are not limited to a particular type of vegetation. McLaren (1975) found that several wood warblers in central Ontario demonstrated considerable latitude in the vegetation used for foraging and nesting. The blurring of avian habitat preferences as a consequence of broadly-defined habitat types may be an unavoidable aspect of transect surveys where the likelihood of encountering substantial amounts of pure and finely-defined habitats is small.

Nevertheless, the species that we found to be typical of the habitats we encountered are in fairly close agreement with Erskine's (1977) conclusions about boreal bird communities and our data show that these representative species are likely to be found even in relatively isolated outposts of particular habitats. For example, deciduous and mixed forest along the Wetiko Hills are rare habitats in this part of the boreal forest (Rowe 1972), yet several species previously reported only from areas 100 to 150 km farther south occur there in minimum densities of 3-8 birds/km^2 (e.g., Golden-crowned Kinglet, Black-and-white and Nashville warblers, Ovenbird). The Tyrrell Sea Beach, an ancient beach ridge, is dominated by well-drained spruce forest generally taller than 7 m, and is surrounded by extensive areas of black spruce muskeg scrub generally less than 5 m tall. On the beach ridge Ruby-crowned Kinglets occur in detected densities up to 8 birds/km^2 whereas detected densities in the surrounding scrub are only 1-2 birds/km^2. Yellow-rumped Warblers show a similar pattern of low densities in the scrub forests of the Hudson Bay Lowlands and Forest-Tundra Transition and high densities

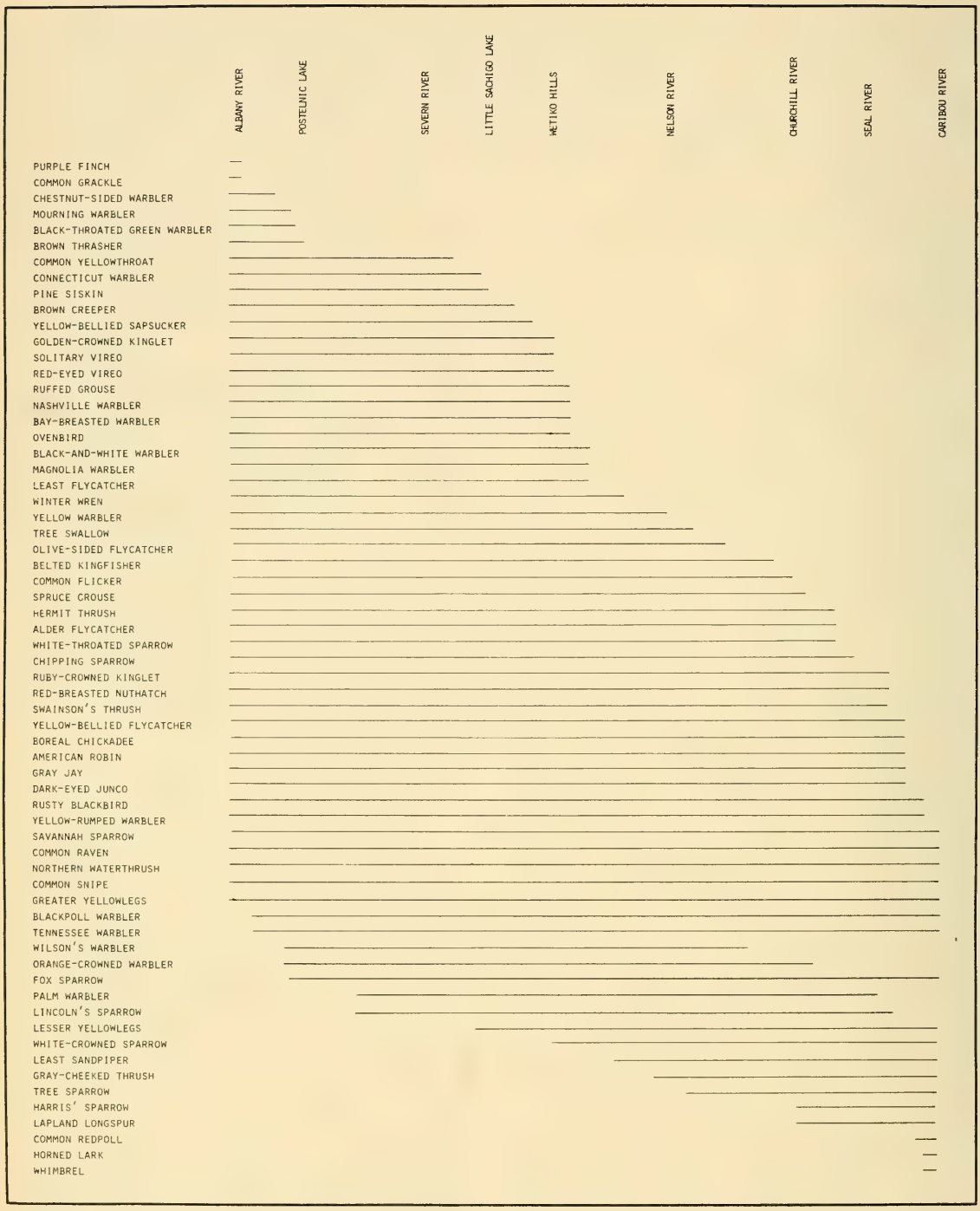

FIGURE 3. Observed ranges of some commonly detected species in northwestern Ontario and northeastern Manitoba, based on both on- and off-transect data.

along the Tyrrell Sea Beach. This is apparently a response to the height of the trees since these species are as abundant in the muskeg forests between Pickle Lake and Little Sachigo Lake as they are on the Tyrrell Beach ridge.

Despite the general agreement between our results and Erskine's (1977), there are a few anomalies. Some of the species Erskine reports as typical were not found in large numbers (or at all) during this study, probably because we were near the limits of (or beyond) their breeding ranges. For example, the American Redstart (*Setophaga ruticilla*) has been reported as common north to about the Severn River in our study area (James et al. 1976). However, we recorded none. Erskine (1977) reported the Dark-eyed Junco to be a typical species in deciduous scrub; although we recorded it commonly, we found none in this habitat. In fact deciduous scrub was the only habitat other than tundra where juncos were not seen. On the other hand, we found Wilson's Warblers and White-crowned Sparrows to be among the most abundant species in deciduous scrub. Gillespie (1960) also found White-crowned Sparrows abundant in this habitat. That Erskine (1977) does not list these species as typical of deciduous scrub is likely again a function of range. Most of Erskine's study plots were well to the south of the range of these two species.

Acknowledgments

The work reported here was part of a larger study of bird populations funded by the Polar Gas Project. We thank L. Doran and B. Ross of the Polar Gas Project for their logistic support. W. McKeever of Viking Helicopters Ltd. piloted the helicopter.

The surveys were conducted by the authors and by C. Holdsworth, W. G. Johnston, E. Nol, and W. Renaud of LGL Ltd. We thank W. J. Richardson of LGL Ltd. and L. Doran and J. Riddick of the Polar Gas Project for their comments on the manuscript.

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Received 28 April 1980
Accepted 25 March 1981

Status and Breeding Success of New Brunswick Bald Eagles

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Stocek, R.F., and P.A. Pearce. 1981. Status and breeding success of New Brunswick Bald Eagles. Canadian Field-Naturalist 95(4): 428–433.

Aerial surveys of New Brunswick for Bald Eagle (*Haliaeetus leucocephalus*) nests in 1974-80 showed 19 occupied sites, all but one in the southwest of the province. The maximum noted in any year was 12. Fifty-three percent of breeding pairs produced young, an average of 0.73 young per occupied site annually, fitting the pattern of marginal production in Atlantic Canada and adjacent Maine. Past brood size of the eagle, never a common breeding bird in New Brunswick, appears to have been comparable to the present. Many former breeding sites are still occupied. There was no relation between breeding success and remoteness or accessibility of the nest, but coastal nesters seemingly were more successful than those in lake and river habitats.

Key Words: Bald Eagle *Haliaeetus leucocephalus*, breeding success, New Brunswick.

The Bald Eagle (*Haliaeetus leucocephalus*) occurs in New Brunswick as both a resident and a transient bird (Squires 1976). Declining populations have been documented in several regions of the United States in the last three decades (Broley 1958, Sprunt et al. 1973). In Canada, Godfrey (1970) regarded the species as endangered, but the Committee On the Status of Endangered Wildlife in Canada (COSEWIC) has not recognized it as such. More recently, scattered attempts have been made to assess regional Bald Eagle populations in Canada, and large, healthy populations have been reported in Saskatchewan and Manitoba (Whitfield et al. 1974, Leighton et al. 1979). In New Brunswick, the bird is now protected under provisions of both the provincial Endangered Species Act and the Fish and Wildlife Act. The present investigation was undertaken to define the past and present reproductive status of the Bald Eagle in that province.

Methods

Published and unpublished records of the breeding occurrence and productivity of the Bald Eagle in New Brunswick provided the data base on which the plan field surveys. Sources of information included New Brunswick Museum, the former Northeastern Wildlife Station at University of New Brunswick, New Brunswick Departments of Natural Resources and of Tourism, federal Departments of Fisheries and Oceans, Environment, and Indian and Northern Affairs, and the Canadian Nature Federation.

Field work during 1974-80 consisted mainly of aerial surveys, for identification of important nesting areas and assessment of production. Most flying was done in Cessna 172, 180, 336, and Piper Cherokee aircraft, with helicopter support (Jet Ranger II, and Huey and Kiowa military units), particularly in 1979 and 1980. The pilot and one other observer usually constituted the crew, although as many as five observers were used at one time. Flying altitude and air speed varied between 35 and 65 m and 110 and 160 km/h, respectively.

During 1974 a strip approximately 0.4 km wide was surveyed along the entire coast, following the forest edge, a distance of about 1 600 km. Flying was undertaken inland to search lake shores and rivers, including those with known or suspected breeding sites. Thirty-four hours of surveys were flown in that year. During 1975, 1976, and 1977 only known and suspected mainland nests were checked from the air. Only ground checks were made in 1978. A more intensive aerial search of lakes and rivers and the southern coast was conducted in 1979, while all known and suspected nests were again inspected in 1980.

Nests were checked from the air at least twice in each breeding season, during incubation and again when advanced nestlings were expected to be present. Supplementary ground checks were infrequent and often consisted of only one visit. Assessment of reproduction is based on terminology proposed by Postupalsky (1974), as follows: an area containing at least one nest was termed a breeding site; a site was judged to be occupied if two adults were present on or near the nest, or if one bird was near a new or repaired nest; and an occupied nest in which at least one young was reared to an advanced stage of development was deemed productive or successful.

A wilderness value was developed for each occupied site in 1979, using a modification of the criteria and method of Mathisen (1968). Each factor — human activity, presence of roads, timber cutting, surrounding habitat, and nest visibility — was evaluated from the air, on a scale of 0 to 4. All factors were averaged for each breeding site. A score of 4.0 represented a site that was remote and considered relatively free of

potential human disturbance, while a value of 0.0 indicated a nest site that was very accessible and disturbance prone. The wilderness value is somewhat subjective but it allows quantification and comparison of breeding sites.

Results and Discussion

Breeding Occurrence and Density

The Bald Eagle seemingly was never a common breeding bird in New Brunswick (Moore 1928). There are records of only 30 nestings in 1900-49, and 75 in 1950-73, no more than five being noted in any one year. Eagles regularly nested on Grand Manan Island, in the Bay of Fundy (Herrick 1873, Pearsall 1879, Boardman 1903, Pettingill 1939). Three or four pairs continue to nest each year on the Canadian Islands south of the Charlotte County mainland including the Grand Manan archipelago. Nesting also occurred on the mainland coast of Charlotte County (Chamberlain 1882) and in the St. Croix Valley (Boardman 1903). Today, two or three pairs still nest near the coast, and the St. Croix River watershed has some sites that have been occupied for over 25 years. No breeding is known from the Bay of Fundy east of Saint John.

In northern New Brunswick, the only early record of nesting eagles is from Northumberland County (Philipp and Bowdish 1977). Very few nests have been seen in the northern counties of Victoria, Madawaska, Restigouche, and Gloucester. The only recent occupied site in that region was on the Tabusintac River, Northumberland County, where eagles have nested for 20 years. The large Miramichi watershed in that county supported only a few nesting pairs, the last being reported in the 1950s.

The estuary of the St. John River up to Fredericton contains preferred nesting habitat for Bald Eagles. They are known to have nested there since at least 1900. A cliff nest was reported at Upper Greenwich, Kings County, in 1911 (Townsend 1912), and a nest at the mouth of Noonan Stream, Sunbury County, about 1920 was said to have been occupied for many years (N.E. Wildlife Station files). There were four occupied sites in the estuary in the 1970s. Between 1950 and 1980, 36 occupied eagle nests involving at least 13 breeding sites, were recorded for that part of the river, although up to 100 birds summered there in 1949-50 (Wright 1953). That summering population was composed largely of the southern subspecies (*H.l. leucocephalus*) (Squires 1976), and has since declined (Stocek 1979).

The distribution of nest sites in New Brunswick in 1974-80 is shown in Figure 1. All but one were in southwestern New Brunswick between the estuary of the St. John River and the border with the State of Maine. During our investigation, 19 occupied sites were found in that part of New Brunswick. A density of 0.11 occupied sites per 100 km^2 was estimated for that region in 1980. Other published estimates of eagle nest density in eastern Canada included 0.08 per 100 km^2 for western Labrador in 1970-73 (Wetmore and Gillespie 1976), and 0.77 occupied sites per 100 km^2 in Cape Breton Island, Nova Scotia (Stocek 1980). Three-quarters of the occupied sites in New Brunswick were near lakes or along rivers and streams, including the Tabusintac, Kennebecasis, St. Croix, St.John, Mactaquac, Canoose, and Portobello. Most of the remainder were on coastal islands. Province-wide, 22 occupied sites have been identified since 1970. During any one year, the maximum number was 12 (0.02 per 100km^2). Since 1950, Bald Eagles have nested in all counties except Kent, Westmorland, Albert, and Saint John. Only two breeding sites are known in neighboring Maine above 46° N latitude (C.S. Todd and R.B. Owen, unpublished data). We found only one breeding site above that latitude in New Brunswick.

To determine the amount of available nesting habitat used by Bald Eagles we measured the shoreline of major lakes and rivers. Primary and secondary habitat were identified, for purposes of comparison of nest density, according to criteria of Leighton et al. (1979), i.e. primary shoreline comprised lakes 11 km or greater in circumference and rivers which were drawn as two distinct lines on 1:250 000 National Topographic Series maps. We searched 1 100 and 2 100 km of total lake and river shoreline, respectively. That included 98% of primary lake habitat and 60% of primary river shoreline in the province. The five southwestern counties contain 80% of the province's total lake area, all the larger lakes being found there, and 30% of all the rivers, by length. The density of breeding sites is given in Table 1. The greater use of the southwestern part of the province and the preference for lake habitats are clearly indicated. The apparent lack of discrimination between primary and secondary shoreline suggests that the criteria used in their identification may not be applicable at the low densi-

TABLE 1. Density of Bald Eagle breeding sites in New Brunswick, by primary and secondary shore habitat

	Number of breeding sites/100 km shoreline			
	Whole province		Southwestern counties	
Habitat	primary	secondary	primary	secondary
Lake	0.76	0.71	0.93	0.88
River	0.41	0.26	0.80	0.74
Total	0.52	0.45	0.86	0.82

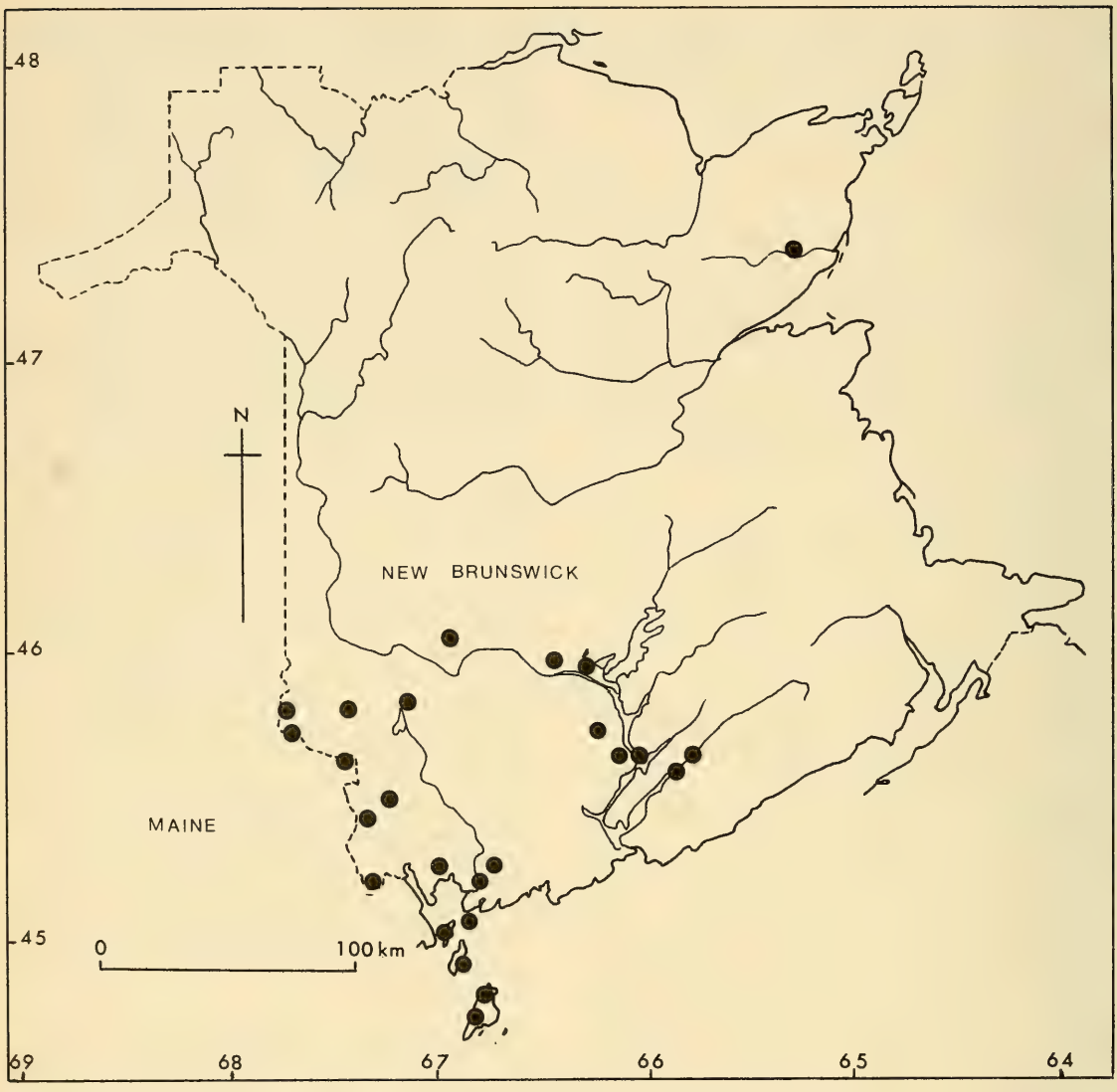

FIGURE 1. New Brunswick, showing locations of Bald Eagle nest sites, 1974-80.

ties of eagles prevailing in New Brunswick. Marine breeding areas were found only on the southwest coast, where breeding site density was 1.39/100 km shoreline, compared with 0.38/100 km for the total provincial coastline. On the outer islands, the breeding site density was 2.23/100 km shoreline. In contrast, breeding site densities of eagles were as high as 5.79/100 km primary shoreline in Saskatchewan in 1974.

Breeding Site Characteristics

Bald Eagle nests were usually constructed in the upper crown of a dominant tree in the forest or in a large, solitary tree on intervale land. Nest habitats ranged from flooded hardwood stands in lowland river valleys to mixed stands on steep hillsides. Seventeen of 25 nests were built in hardwood trees. All nests in softwoods were in white pine. Twenty-one of 25 nest trees were living. We know of no recent cliff nests in New Brunswick. Gittens (1968) reported that 24 of the 50 nests he investigated in Nova Scotia were in hardwoods, especially aspen, and 16 in white pine. He also noted that four of 50 nests of Cape Breton Island were on cliffs.

Of 26 nest sites we studied, 13 were within 100 m of water and only two were more than 500 m from water. Four of the inland nests were located on small lakes or streams near major bodies of water rather than on the larger waterways themselves. Seven of 18 breeding sites had alternate or supernumerary nests, ranging up to 5 km away. Based on years of occupancy and breeding history at the site, we considered those distant nests to be parts of the same breeding sites. One nest tree contained two nests, only one occupied at a time.

The wilderness value scores of 11 sites occupied in 1979 ranged from 1.2 to 4.0. There appeared to be no relationship between the success of a nest and the wilderness rating of the site. The unsuccessful and successful sites had mean scores of 3.5 and 3.1, respectively. The two most remote sites failed to produce young, and the site most susceptible to actual human activity was successful. However, because of typically adverse weather in New Brunswick during early spring when Bald Eagles start breeding, human activity on lakes and rivers is often not underway until June; by then eggs have hatched and the chances of nest desertion are reduced, although snowmobiling and winter cutting may create disturbance in some areas earlier in the breeding cycle.

Breeding and Productivity

Bald Eagles start moving to nesting areas in New Brunswick in February and March. Incubating birds have been noted as early as 25 March and eggs have been seen from 6 April to 16 May. On Grand Manan Island, Herrick (1873) reported finding eggs with well-developed but frozen embryos on 20 February. Peak egg laying occurs in early April. Information in the Maritimes Nest Records Scheme indicates that the mean clutch size of the Bald Eagle in the Maritime Provinces, based on 13 full clutches, was 2.15 ± 0.55 - 1 × 1e, 9 × 2e, 3 × 3e. Our investigation showed that nests contained young from 23 May to 10 August. We found 19, nine, and one, nests with one, two, and three young, respectively. Peak fledging takes place in late July. In Nova Scotia, eggs hatched between 10 and 25 May and young fledged between 15 and 30 July (Gittens 1968).

Figures for eagle productivity are shown in Table 2. During our study, 53% of the breeding pairs were successful. The average number of young produced annually was 0.73 and 1.38 in occupied and successful nests, respectively. Data on 17 successful nests in 1960-73 gave an average fledgling brood size of 1.43. Sprunt et al. (1973) estimated that at least 50% of breeding pairs should rear young, with a mean of 0.7 young yearly per occupied nest, to maintain a stable population. Only 60% of the breeding pairs in New Brunswick were successful at least half of the time. Generally poor nesting success has resulted in low annual production of young. Information on the breeding success of eagle populations elswhere in Atlantic Canada and in Maine (Table 3) indicates that New Brunswick fits the regional pattern of marginal production.

Broods of two young were seen in 9 of 29 successful nests. Two young also were noted in about one-third of successful eagle nests in Nova Scotia (Gittens 1968) and in Maine (C.S. Todd and R.B. Owen, unpublished data). In the larger, more productive populations in Saskatchewan and Manitoba (Whitfield et al.

TABLE 2. Productivity of Bald Eagles in New Brunswick, 1974-80[1], by year and habitat

Year	Number of breeding sites			Young raised/nest	
	Examined	Occupied (followed through)[2]	Successful	Occupied	Successful
Year					
1974	11	10 (8)	4	0.63	1.25
1975	12	10 (9)	3	0.56	1.67
1976	12	9 (5)	1	0.20	1.00
1977	12	8 (7)	5	1.00	1.40
1978	6	6 (3)	2	1.00	1.50
1979	17	12 (11)	6	0.64	1.17
1980	18	12 (12)	8	1.00	1.50
Habitat					
Coastal	15	11(6)	6	1.66	1.66
Lake	40	33(27)	11	0.48	1.18
River	33	23(22)	12	0.77	1.42

[1]No aerial surveys were conducted in 1978.

[2]Not all occupied nests could be followed through to success or failure.

TABLE 3. Bald Eagle breeding success in Atlantic Canada and adjacent Maine, U.S.A.

Area (Source)	Period	Number of occupied breeding sites	% Successful	Young raised/nest	
				Occupied	Successful
Labrador (Wetmore and Gillespie 1976)	1970-73	24	45	0.60	1.20
Maritime Provinces (Stocek and Pearce, unpublished data)	1975	28[1]	54	0.80	1.53
Nova Scotia (Gittens 1968)	1968	23	54	0.72	1.36
New Brunswick (this study)	1974-80	67	53	0.73	1.38
Maine (C.S. Todd and R.B. Owen, unpublished data)	1977-78	112	39	0.60	1.52

[1]Includes 9 sites in New Brunswick also used in this study.

1974), northwestern Ontario (Grier 1974), and Alaska (Sprunt et al. 1973), two young were also produced in about one-third of successful attempts. Almost 80% (67/88; Table 2) of the breeding sites examined were occupied during our investigation. Five of 13 sites occupied in 1974-75 were no longer being used in 1980.

Birds nesting in marine environs appeared to be more successful than those occupying lake and river breeding sites ($P < 0.01$, t-test) (Table 2). Breeding success in freshwater habitats showed no significant difference. A habitat-related disparity in breeding success was also mentioned by C.S. Todd and R.B. Owen (unpublished data) for eagles in Maine in 1977-78: they credited birds on the coast and inland lakes with greater success than those in river habitats.

Acknowledgments

Thanks are expressed to J. C. Baird and the late B. S. Wright for their assistance, and to biologist-pilot A. Boer who gave freely of his time, often on short notice. The authors are particularly indebted to the 422nd Tactical Helicopter Squadron, Canadian Forces Base Gagetown, for permission to travel with the unit on training missions. Financial support was provided by Canadian Wildlife Service, New Brunswick Departments of the Environment and of Natural Resources, World Wildlife Fund, Canadian Wildlife Federation, Samuel and Saidye Bronfman Family Foundation, Quebec-Labrador Foundation, Inc., Tractors and Equipment 1962 Ltd., Fredericton Fish and Game Association, and Moncton Fish and Game Association. New Brunswick Wildlife Federation assisted in obtaining funding. The help of the New Brunswick Fish and Wildlife Branch, Forest Service, Electric Power Commission, and Museum is also acknowledged with gratitude. H.W. Blenis, Maritime Forest Ranger School, provided encouragement and administrative support.

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Received 17 September 1980
Accepted 21 March 1981

The Biological Flora of Canada.

3. *Vaccinium vitis-idaea* L. var. *minus* Lodd. Supplementary Account..*

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Hall, Ivan V., and Jennifer M. Shay. 1981. The Biological Flora of Canada. 3. *Vaccinium vitis-idaea* L. var. *minus* Lodd. Supplementary account. Canadian Field-Naturalist 95 (4): 434-464.

Vaccinium vitis-idaea var. *minus* is a widely distributed evergreen dwarf shrub of northern temperate, boreal and arctic areas in North America. Rapid dispersal of seeds by birds and mammals through their droppings, followed by good seed germination and seedling establishment, permits this species to colonise burned forests and open habitats. Its evergreen characteristics and low growth form permit effective photosynthesis and growth in northern climates because its niche is the warmer microclimate at the soil surface. Plants flower in Canada from mid-June to early August depending on location, and the berries generally mature in late August or early September. Berries are of low pH, moderate caloric content and are high in tannin and anthocyanin.

Key Words: *Vaccinium vitis-idaea* var. *minus*, Partridgeberry, Fox Berry, Lingonberry, biology, ecology, physiology, distribution, economic importance.

1. *Name*

Vaccinium vitis-idaea L. var. *minus* Lodd., section Vitis-Idaea; Ericaceae
Vaccinium vitis-idaea spp. *minor* (Lodd.) Hultén (Hultén 1937, 1949),
Vaccinium vitis-idaea L. (Scoggan 1979); Mountain-cranberry, Rock Cranberry, Cowberry, Lingen, Lingberry, pommes de terre (Fernald 1950), Partridgeberry (Rouleau 1956), airelle-d'Ida (Marie-Victorin 1964), Lingonberry (Hultén 1968), Fox Berry (Roland and Smith 1969), Redberries (Bourchard et al. 1978); Dry-ground Cranberry (Looman and Best 1979); berris, graines rouges (Scoggan 1979).

2. *Description of the Mature Plant*

a) Raunkiaer life-form. Chamaephyte. Evergreen dwarf creeping shrub, reproducing by seeds and rhizomes.

(b) *Shoot morphology.* Stems semi-woody, up to 15 cm high, 1-2 mm diameter, puberulous, the bark with a reddish tinge in late autumn; terminal flower buds larger than the vegetative buds; evergreen leaves alternate in a spiral (Figure 1), simple, petiolate, 5-18 mm long, 3-9 mm wide, somewhat leathery, pinnately net veined, margin slightly revolute, obovate, apex mucronate to emarginate, base cuneate, the upper surface dark green, purplish in autumn, the lower surface waxy, pale green with black glandular dots; slender creeping stems semi-woody, bearing numerous shoots, new growth white or pinkish. Occasionally produces rhizomes not morphologically distinct from stems (Shaver and Cutler 1979).

(c) Root morphology. Tap root with finely divided rootlets at the extremities (Hall and Beil 1970) (Figure 2), adventitious roots occurring at nodes along the creeping stems and rhizomes (Viereck and Little 1972). Leiser (1968) has described a mucilaginous root sheath surrounding the root tip.

(d) Inflorescence. Flowers occurring singly or in racemose clusters (Figure 1), "the most common numbers being five and six" in Newfoundland (Torrey 1914), at Kentville, Nova Scotia, 5.2 ± 1.6 ($\bar{x} \pm$ standard error used throughout paper) (n = 167). Stems bearing inflorescences at anthesis are 9 cm tall (Pojar 1974). Flowers pedicellate; sepals 4, green (pinkish in dried specimens), deltoid, 1.5 ± 0.0 mm diameter (n = 42); petals 4, the corolla pinkish-white, bell shaped, corolla lobes free for half their length, 4.7 ± 0.5 mm long (n = 42), 4.8 ± 0.6 mm wide (n = 42); stamens 8, in 2 whorls, filaments hairy. Pollen is borne in tetrads, and shed from the anther through a terminal pore.

* See J.C. Ritchie (1955).

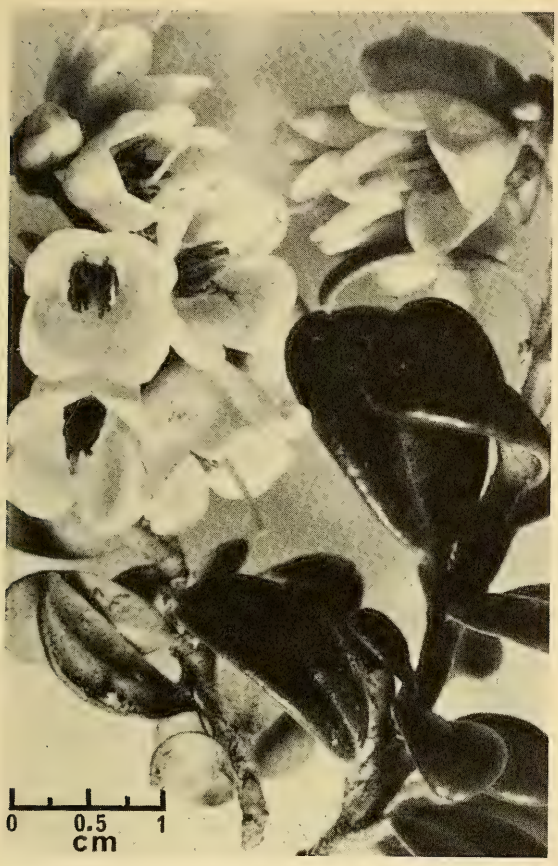

FIGURE 1. Flowers and leaves of *Vaccinium vitis-idaea* L. var. *minus* Lodd.

FIGURE 2. Seedlings of *Vaccinium vitis-idaea* L. var. *minus* Lodd. Approximate age of largest plant 1 yr.

The stigma and part of the style protrude beyond the corolla (Figure 1). The ovary is inferior with many ovules and together with the calyx produce a true berry. Berries are carmine in colour when ripe, globose, nearly 1 cm diameter (Gleason 1958), acid, and have several small seeds per berry (see 7b); seeds are dark brown, elliptic to semicircular, 1.0 × 0.6× 0.5 mm, with a reticulate surface (Montgomery 1977).

(e) Subspecies. Hultén (1949) treats *V. vitis-idaea* L. var *minus* as a subspecies.

(f) Varieties. We have followed Fernald (1950) who considered the smaller North American form as a variety (*Vaccinium Vitis-Idaea* L. var. *minus* Lodd.) and the larger European plant as variety *vitis-idaea.*

(g) Ecotypes. None recognized in North America.

(h) Chromosome numbers. 2n = 24 has been reported by Newcomer (1941) from plants collected in N. Carolina and Tennessee, by Taylor and Mulligan (1968) from a collection southeast of Port Clements in the Queen Charlotte Islands, B.C., and from the IBP sites at Barrow Alaska by Packer and McPherson (1974). The European *V.vitis-idaea* var. *vitis-idaea* also has 2n = 24 (Ritchie 1955, Sorsa 1962, Hedberg and Hedberg 1964, Rousi 1966, 1967, Laane 1969).

3. *Distribution and Abundance.*

(a) Geographic range. Vaccinium vitis-idaea var. *minus*, a native species listed by Macoun (1884), occurs widely in north temperate, boreal and arctic regions. In North America it extends from eastern Newfoundland to Alaska and British Columbia (Figure 3, Table 1). It has been collected along the north coast of Alaska, in the

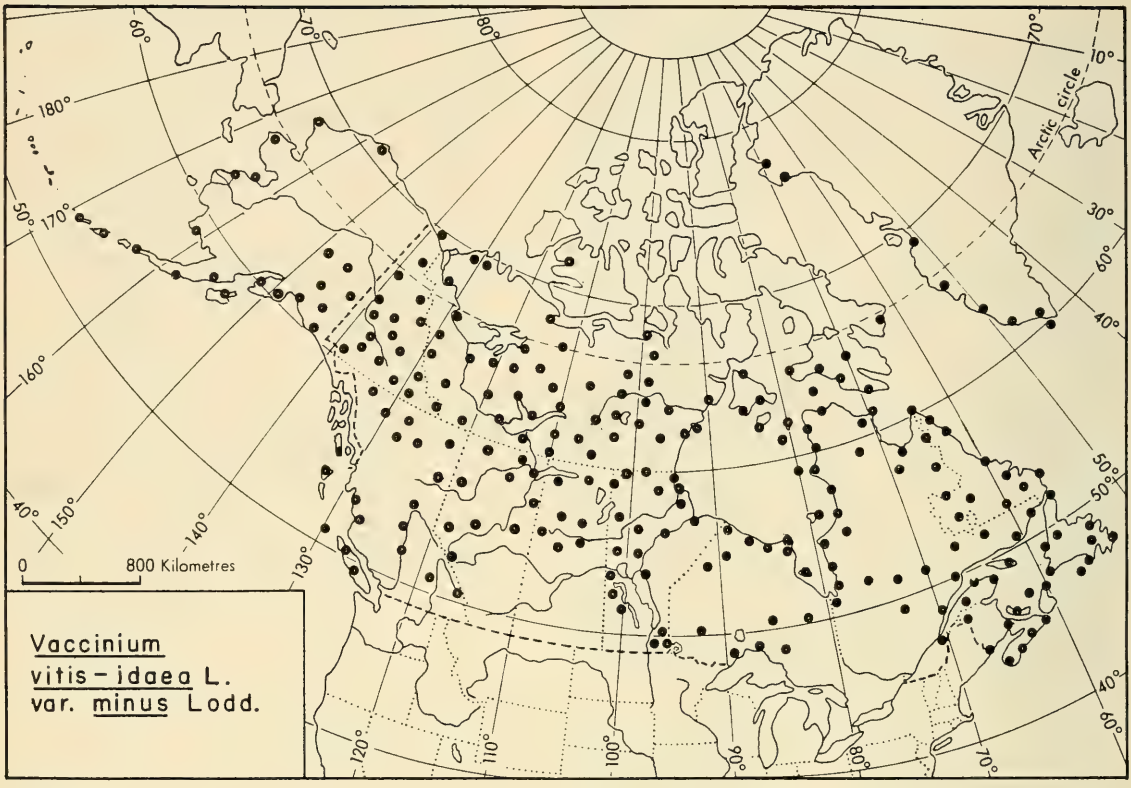

FIGURE 3. Distribution of *Vaccinium vitis-idaea* L. var *minus* Lodd. from specimens in the herbaria of Canada Agriculture, Ottawa, Ontario (DAO), National Herbarium, National Museum of Canada, Ottawa, Ontario (CAN), Acadia University, Wolfville, Nova Scotia (ACAD), University of Manitoba, Winnipeg, Manitoba (WIN), and University of Alberta, Edmonton, Alberta (ALTA).

Mackenzie District, Victoria Island, Keewatin (Scoggan 1979) and southern Baffin Island (Polunin 1948). It ranges southward to northern Minnesota and New England (Scoggan 1979). Porsild and Cody (1980) map the N. American distribution, Ritchie (1962) gives Manitoba sites and a map of Alaska sites is contained in Viereck and Little (1975). Beyond North America it has been recorded in Greenland up to 78° N and in eastern Asia (Hultén 1948). Eurasian distribution of var. *vitis-idaea* is given in Ritchie (1955). Distribution maps are listed in Hultén (1971) and include those of Meusel (1943), Raup (1947) Szczawinski (1962), Porsild (1964), Hultén (1968,1971).

(b) Altitudinal range. In Eastern Canada this species extends from about sea level to the summits of the Shickshock (elevation 1290 m), Gaspé Peninsula, and Torngat Mts. (elevation 1200 m), Newfoundland. On Mount Washington (elevation 1700 m), New Hampshire it is found on north and west slopes (Bliss 1963). It occurs from valley bottoms to well above treeline in the Alberta Rockies (elevation 2250 m) (Hrapko and La Roi 1978). Throughout the northwest it occupies habitats of various altitudes including the lower elevations of the Mackenzie Mts., Northwest Territories, and the Ogilvie (1350m) (See and Bliss 1980), and St. Elias Mts. (up to 1500 m) (Birks 1977), and the Alsek River region (2100-2400 m) in the Yukon (Douglas 1974). Populations of this species at the highest elevations are less vigorous and have small leaves with short internodes. At sea level in southern Alaska it grows vigorously (Cushwa and Coady 1976). It occurs around Hudson Bay on uplands, islands and in estuarine habitats.

4. *Physical Habitat*

(a) Climatic relations. The major part of the plant's distribution lies within Thornthwaite's (1931) Dfc climatic

region, characterised as semi-arid with short, cool summers and long, cold winters. It occurs within the arctic, subarctic, cryoboreal, boreal and mesic climatic soil classes (Clayton et al. 1977a).

Larsen (1971a) suggests that in central northern Canada boreal forest and tundra, correlations with air mass frequencies are sufficiently high to warrant the conclusion that the distribution of *V. vitis-idaea,* one of the dominant species in Black Spruce, White Spruce and Jack Pine forests, is related to arctic air mass distribution and frequency. But in rock field (fell-field) tundra and tussock muskeg tundra, *V. vitis-idaea* distribution and frequency are related to warm, moist Pacific air mass frequency.

Due to their northerly distribution, plants must withstand extreme cold and prolonged cover by snow. The latter may be an advantage because ample snowcover is necessary to protect the leaves from snow abrasion (Savile 1972). On Mt. Washington it dominates dwarf shrub communities where winter snow is deep but melts early in the spring (Bliss 1966). In contrast, Hrapko and LaRoi (1978) report that *V. vitis-idaea* var. *minus* has high cover in the *Dryas octopetala** (Dryas) — *Empetrum nigrum* (Crowberry) community type where snowmelt is late. In Greenland it can survive snow cover for more than a year (Warming 1908). Resumption of growth is governed by the timing of snow melt (Wielgolaski 1974). Both light (Oldemeyer and Seemel 1976) and moisture are important influences on development and growth. In Nova Scotia, maximum flower bud formation occurs in open exposed sites, although in Alberta bud formation was greatest in the shade of *Populus tremuloides* (Trembling Aspen) (Smith 1962) where moisture was greater. Lehmushovi (1977) states that in Finland the more open and better illumined the habitat, the higher the fruiting percentage. The effect of temperature is shown by later flower anthesis in coastal and more northerly sites. The low growth habit and shallow root system of *V. vitis-idaea* enable it to take advantage of the warmer microenvironment found at ground level. Ritchie (1955) suggests that temperature is the critical factor that limits its southern distribution in England. He reported significant temperature differences between the southern heath areas where *V. vitis-idaea* was present and absent. In field plantings at Kentville following the normal winters of 1978-79 and 1979-80, when maximum January temperature was 15°C and the minimum −19.5°C, all native *Vaccinium* species, including *V. boreale* (Sweet Hurts), *V. myrtilloides* (Sour-top Blueberry), *V. angustifolium* (Lowbush Blueberry) and *V. vitis-idaea* var. *minus* survived without winter injury, whereas the European *V. vitis-idaea* (Cowberry) plants had mostly brown, withered leaves and *V. myrtillus* (Dwarf Bilberry) had the stems killed to ground level (personal observation I.V.H.).

(b) Physiographic relations. Vaccinium vitis-idaea occupies a wide range of habitats growing in extreme exposure on headlands, sea cliffs, rocky hilltops, eskers and mountain summits, and in more sheltered sites in Black and White spruce forests. It is found on low flat areas, gentle to steep slopes (Larsen 1972b) and mountainous terrain (Hrapko and LaRoi 1978).

At Caribou Lake, northern Manitoba, it was a principal component of the south- and east-facing slopes of eskers and moraines but was absent on the snowless northwest side (Ritchie 1960a). In contrast, near Inuvik (Ritchie 1977) *V. vitis-idaea* was absent in the open forest on south-facing slopes and had a frequency of 40% and cover of 3% on north-facing slopes. North-facing slopes in the Pelly Lake area had the greatest moisture and supported more or less continuous vegetation which included *V. vitis-idaea* with a mean frequency of 80% (Larsen 1972b).

Parent material may be sandstone (Hall *et al.* 1964), limestone (Polunin 1948, Rickard *et al.* 1965) schist, gneisic or granite rock, glacial outwash plains of coarse sand and gravel (Larsen 1971a) or peat (Ritchie 1960a, Haag 1974). *Vaccinium vitis-idaea* is found on gray luvisols, humoferric podsols, dystric brunisols, orthic and cryic regosols, gleysols and cryic gleysols, fibrisols, mesisols, and rockland (soil classification after Clayton *et al.* 1977a) and histic cryaquepts (peaty phase of orthic gleysol) with 15 cm peat (Haag and Bliss 1974). Ritchie (1960a) reports it on peat up to 1.5 m deep. Soil pH is generally acid, it may be 3.0-3.9 (Dugle 1972), 4.5-4.7 (Barclay-Estrup and Nuttall 1974), 4.9 (Swan and Dix 1966), or 5.4 (Haag 1974). *Vaccinium vitis-idaea* var. *minus* was common in a Larch fen (*Larix laricina*) with a pH 7.0-8.2 (Ritchie 1960b).

The Orthic Gleysols described by Hrapko and LaRoi (1978) had the following characteristics: pH 5.2, N = 0 ppm, p = 5 ppm, and K = 127 ppm. Their field capacity was 46%, permanent wilting point 27% and available water 19%. Eutric Brunisols and Orthic Gleysols at Tuktoyaktuk had a 10-15 cm organic layer with a total exchange capacity of 77.4 meq/100 g overlying a thin, discontinuous Bg horizon (total exchange capacity 118.1 meq/100 g). The permafrost maximum active layer was 35-50 cm at the end of the summer (Haag 1974), and ranged from 29-112 cm.

In the southern part of its range *V. vitis-idaea* var. *minus* occurs most frequently in bogs and relatively moist

*Nomenclature follows Scoggan 1979

sites, although further north it frequents dry to moist sites (Polunin 1948, Larsen 1971b, 1972a) or those that are well to moderately drained (Ritchie 1960b; Lavkulich 1973). It grows in moist sites as well as those with a slight moisture deficit. Larsen (1972b) pointed out that differences in moisture rather than soil type governed *V. vitis-idaea* distribution at Pelly Lake, for it flourishes best where there is some moisture retention. In the peat soils around Little Catalina on the Bonavista Peninsula, Newfoundland, the linear growth was three to four times that on the drier mineral soils nearby (personal observation I.V.H.).

(c) Nutrient and water relations. Vaccinium vitis-idaea nutrient requirements are low being satisfied by soils that are shallow or of low fertility. It is generally shallowly rooting (Shaver and Chapin III 1980) but may root from 0-30 cm (Hrapko and LaRoi 1978). Rhizomes and roots grow well in peat, but often penetrate and grow in mineral layers (Weber 1974, Shaver and Cutler 1979), the latter also found roots concentrated in the structured dead zone, below the living moss. In Britain the rhizomes are invariably confined to the humus layer (Ritchie 1955).

Haag (1974) fertilized a dwarf shrub-heath community dominated by *Betula nana* ssp. *exilis* (Dwarf Birch) and *Salix glauca* (Willow) with a prostrate ground cover of *V. vitis-idaea* var. *minus, Ledum palustre* (Northern Labrador-tea) and *Empetrum nigrum* var. *nigrum* using 100 and 200 kg/ha ammonium nitrate (34% N) and 100 and 200 kg/ha superphosphate (20% P). The applications of N increased production by 15% and 30% by 12 July, and to 45% and 68% by 6 August at low and high rates respectively. Phosphorus at low rates decreased total production 20% but increased it 4% at high rates. When N and P were combined, total production increased 15% and 30% on 7 July and 35% and 75% by 6 August. This indicates that total primary production is limited more by available soil N than P.

5. *Plant Communities*

Vaccinium vitis-idaea var. *minus* is a northern plant and like its European counterpart (Ritchie 1955) occurs primarily in the Boreal Forest and Tundra regions (Rowe 1972). It is found in a range of communities including forests (Moss 1953a, 1953b; Ritchie 1956, 1959, 1960a, 1960b; LaRoi 1967., Blouin and Grandtner 1971, Bouchard et al. 1978), various types of muskeg (Larsen 1965, Ritchie 1960b), bog, fen (Ritchie 1960b), peatlands with feather mosses and/or Sphagna (Calder and Taylor 1968, Railton and Sparling 1973); arctic-alpine tundra (Porsild 1937; Bliss 1966; Porsild and Cody 1980), and other communities characterized by their physiography such as rock outcrops, eskers and rockfields (Larsen 1965), dunes (Grandtner 1977), and heath barrens along coasts (Torrey 1974; Marie-Victorin 1964).

Data showing the abundance of *Vaccinium vitis-idaea* var. *minus* and the location of a selection of communities containing it are given in Tables 1 and 2. LaRoi (1967) found it present in 35% of the White Spruce and 42% of the Black Spruce stands in an east-west arc across the Boreal Forest. In the east its presence in the Acadian (Roland and Smith 1969) and Great Lakes-St. Lawrence Forest Regions (Blouin and Grandtner 1971) is more limited. In the west it forms part of Rowe's (1972) Mixedwood Forest Region (Swan and Dix, 1966, LaRoi 1967, Larsen 1972a, Shay and Shay 1979) and it occurs westwards to the Northern Pacific Coast (Pojar 1974). Many studies have reported it in arctic and alpine locations (Polunin 1948, Cody 1954b, Bliss 1963, 1966, Birks 1977, Hrapko and LaRoi 1978).

6. *Growth and Development*

(a) Morphology. The oblong-elliptical cotyledons are ca. 2 mm in length. The first true leaves are nearly ovate and less than one-third the size of fully mature leaves. Rhizomes begin to grow on seedlings 5 cm in height (Figure 2). Lateral growth of plants is slow, being ca. 2 to 4 cm per year at Kentville. Bliss (1966) studied growth at 1600 -1800 m on Mt. Washington, New Hampshire and found that plants elongated 0.05-0.1 cm in 3-day periods, and that over four years, mean shoot elongation in *V. vitis-idaea* ranged from 0.8-1.8 cm per year. Bliss (1962b), in a review article on the adaptations of arctic and alpine plants to environmental conditions, states that work in Russia by Zhuikova showed that most plants of *V. uliginosum* (Alpine Bilberry), *V. myrtillus,* and *V. vitis-idaea* did not flower until 14-20 years of age. Ritchie (1955) indicated that, in cultivation, few flowers are formed in *V. vitis-idaea* before plants are 5-10 years old.

In a pine forest in Sweden, Teär (1972) found that in four year old plants, stems of *V. vitis-idaea* were monopodial with 2 to 3 shoots per stem and 3 to 4 stems per plant. At least one stem (approximately 4 cm long) is produced each year, the number depending on plant size. Fertile shoots have more leaves than sterile ones and produce one flower bud containing 5-6 flowers. On the other hand, plants on farmland were more branched and stems were sympodial with 6 to 12 stems per plant (2 cm long). The number of leaves per running cm was greater than in the pine forest and two flower buds per stem were produced instead of one. *Vaccinium vitis-idaea* from

TABLE 1. *Vaccinium vitis-idaea* L. var. *minus* Lodd. in various North American plant communities. Relative abundance based on author's estimates: a = abundant, f = frequent, o = occasional, r = rare, x = present.

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
BOREAL FOREST					
B.2 Gaspé	Bic and Gaspé peninsula	48°-49° N 64°-68° W	Bog, alpine cliff	x	Scoggan (1950)
B.8 Central Plateau	Klotz Lake, Ontario	60° 50′ N 73° 40′ W	Black Spruce forest		Larsen (1972a)
B.9 Superior	Bowman Island, Ontario	48° 44′ N 87° 59′ W	Black Spruce, Balsam Fir	o	Barclay-Estrup & Nuttall (1974)
			Krummholtz	a	
			Lichen heath	o	
B.11 Upper English River	Raven Lake, Ontario	49° 16′ N 91° 12′ W	Black Spruce forest	r	Larsen (1972a)
B.14 Lower English River	West Hawk Lake, Manitoba	49° 53′ N 95° 15′ W	Black Spruce forest	f	Larsen (1972a)
B.15 Manitoba Lowlands	Elma, Manitoba	49° 53′ N 95° 54′ W	open bog	o	Reader and Stewart (1971)
B.18a Mixed wood	Clear Lake, Manitoba	50° 43′ N 100° 01′ W	Black Spruce forest	o	Larsen (1972a)
	Deep Lake, Manitoba	50° 53′ N 100° 51′ W	Black Spruce bog	f	Shay & Shay (1979)
	Prince Albert Nat. Park, Sask. (600 m)	53° 55′ N 106° 37′ W	Black Spruce forest	r	LaRoi (1967)
	Waskesiu Lake, Saskatchewan	53° 55′ N 106° 15′ W	Black Spruce forest	f	Larsen (1972a)
B.18a Mixed wood	Candle Lake, Sask.	53° 50′ N 105° 20′ W	Trembling Aspen forest	r	Swan & Dix (1966)
			White Birch forest	r	
			Jack Pine forest	a	
			White Spruce forest	o	
			Black Spruce forest	o	
	(600 m) Sask.	53° 57′ N 106° 29′ N	White Spruce forest	r	LaRoi (1967)
B.18ab Mixed wood — Hay River	(480 m) Alta.	57° 36′ N 117° 31′ W	Black Spruce forest	r	LaRoi (1967)
B.18b Hay River	Fort Providence, N.W.T.	61° 13′ N 117° 31′ W	White Spruce forest	a	Larsen (1972a)
	(300 m) Alta.	59° 28′ N 117° 11′ W	White Spruce forest	r	LaRoi (1967)
	Horn Plateau, N.W.T.	62° 08′ N 118° 07′ W	Black Spruce forest	o	Thieret (1961)
			Lichen tundra	f	
	Northwestern Alta.	55-60° N 114-120° W	White Spruce forest	o-f	Moss (1953a)
			Black Spruce forest	f-a	
			Sphagnum bog	f	Moss (1953b)
B.19a Lower Foothills	Northwestern Alta.	55-60° N 114-120° W	White Spruce forest	f	Moss (1953a)
			Pine forests	r-f	
			Poplar forests	r-f	
			Black Spruce bog forest	f-a	
			Spagnum bog	f	Moss (1953b)
	Crimson Lake, Alta. (950-1010 m)	52° 26′ N 115° 01′ W	String fen w/ Tamarack	r	Slack *et al.* (1980)
	Swan Hills, Alta. (1300 m)	55° N 116° W	Patterned fen w/ Black Spruce	r	Vitt *et al.* (1975)
	(870 m) Alta.	54° 24′ N 116° 47′ W	Black Spruce	r	LaRoi (1967)

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
BOREAL FOREST (continued)					
B.19b Northern Foothills	(750 m) B.C.	58° 42′ N 123° 40′ W	Black Spruce	r	LaRoi (1967)
	(840 m) N.W.T.	58° 59′ N 125° 47′ W	White Spruce	f	LaRoi (1967)
B.21 Nelson River, Manitoba		54° 36′ N 100° 12′ W	White Spruce forest	r	LaRoi (1967)
B.22a Northern Coniferous	Cranberry Portage, Manitoba	54° 35′ N 101° 23′ W	Black Spruce	o	Zoltai and Tarnocai (1971)
	Gods Lake, Manitoba	54° 23′ N 94° 26′ W	Black Spruce forest	o	Larsen (1972a)
	Ilford, Manitoba	56° 07′ N 95° 20′ W	Black Spruce forest	a	Larsen (1972a)
	(360 m) Sask.	55° 20′ N 105° 05′ W	Black Spruce forest	r	LaRoi (1967)
	(375 m) Sask.	55° 20′ N 104° 58′ W	White Spruce forest	r	LaRoi (1967)
	McBride and Tod Lakes, Manitoba	56° 52′ N 99° 57′ W	Black Spruce forests	f-a	Ritchie (1956)
			Jack Pine woodland	o-f	
		56° 45′ N 101° 48′ W	White Spruce forest	a	
B.22b Athabasca South	Wapata Lake, Sask.	58° 55′ N 105° 37′ W	Black Spruce forest	a	Larsen (1972a)
	Cluff Lake, Sask.	58° 20′ N 104° 35′ W	Trembling Aspen forest	f-a	Harms (1978)
			Mixed conifer-deciduous forest	f-a	
			Black Spruce-Tamarack bog forest	f	
			Shrub, shoreline	o-f	
B.23a Upper Mackenzie	(240 m) N.W.T.	60° 35′ N 116° 07′ W	Black Spruce forest	f	Larsen (1972a)
	(240 m) N.W.T.	61° 03′ N 117° 22′ W	White Spruce forest	f	Larsen (1972a)
	Norman Wells, N.W.T.	65° 17′ N 126° 51′ W	Black Spruce forest	f	Cody (1960)
B.23a Upper Mackenzie	Lower Liard River, N.W.T.	60-61° N 123° 30′ W to 124° W	Black Spruce-feathermoss forest on flood plains	a	Jeffrey (1961)
			Black Spruce-Tamarack forest on floodplains	a	
			Deciduous forest on flood plains	o	
			Black Spruce-Trembling Aspen forest	o-f	
			Black Spruce forest	f	
	(540-690 m)		Lodgepole Pine-lichen woodland	a	
	(480-780 m)		Mixed coniferous forest		
	(780-1140 m)		Subalpine fir	f	
	(1050-1110 m)		Mixed coniferous forest to timberline	o	

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
BOREAL FOREST (continued)					
B.23a Upper Mackenzie	Lower Liard River, N.W.T.				
	(1140 m)		Alpine dwarf scrub tundra	a	
B.24 Upper Liard	Nahanni National Park & vicinity, N.W.T.	61°03′ to 61°58′ N 123°30′ to 128°14′ W	Spruce forest	f	Scotter and Cody (1974)
	(510 m) N.W.T.	60° N 127°43′ W	Black Spruce forest	f	LaRoi (1967)
	(420 m) N.W.T.	59°38′ N 126°50′ W	White Spruce forest	f	
B.26b Central Yukon	Atlin Provincial Park, B.C. - Birch Mountain (2061 m)	59° N 133° W	Alpine fell fields	f	Buttrick (1977)
			Alpine meadow and scrub	o	
B.26c Eastern Yukon	(900 m) B.C.	59°55′ N 131°41′ W	White Spruce forest	o	
	(1290 m) N.W.T.	60°07′ N 130°44′ W	White Spruce forest	r	
B.26d Kluane	St. Elias Mountains, N.W.T.	61°32′ N 140°30′ W	Open Black Spruce forest	o	Birks (1977)
			Dwarf Birch scrub tundra	r-o	
	Alsek River, N.W.T.	60°30′ N 137°30′ W	White Spruce forest	o	Douglas (1974)
			White Spruce treed fen	r	
			White Spruce-Trembling Aspen forest	r	
			Willow shrub	r	
B.27 Northwestern Transition	Caribou Lake, River, Manitoba	59°20′ N 95°10′ W	White Spruce forest	f	Ritchie (1960a)
			Open Black Spruce forest with lichen scrub	f	
			Open Black Spruce forest with moss scrub	a	
			Tamarack forest	o	
	Long Bay, Southern Indian Lake, Man.	56°40′ N 100°10′ W	Black Spruce forest	o-a	Shay *et al.* (nd)
			Open Black Spruce bog	f	
	Seal River, Man.	59° N 96°45′ W	Open Black Spruce forest with lichen scrub	o-a	Ritchie (1959)
			Dwarf scrub heath	a	
			White Spruce forest on flood plains	x	
	Lynn Lake, Man.	56°50′ N 101°30′ W	Black Spruce forest	a	
	Yellowknife, N.W.T.	62°54′ N 114°56′ W	Black Spruce forest	a	Larsen (1972a)
			White Spruce forest	o	
	Abitau-Dunvegan Lakes, N.W.T.	62° N 110° W	Post-fire succession	o-f	Maikawa and Kershaw (1976)
			Moss-lichen to closed spruce forest		

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
BOREAL FOREST (continued)					
B.27 Northwestern Transition	Fort Reliance, N.W.T.	62° 40′ N 109° 07′ W	Black Spruce forest	a	Larsen (1972a)
			White Spruce forest	f	
			Tussock muskeg tundra	a	
	Aubrey & Colville Lakes, N.W.T.	67° 20′ N 126° 15′ W	Open White Spruce with lichen scrub	x	Riewe (1979)
			Cottongrass-sedge on shores and river margins	x	
			Dwarf scrub-lichen heath	x	
			Fens and bogs	x	
B.28a Grand Falls	(270 m) Nfld.	48° 46′ N 56° 14′ W	Black Spruce forest	r	LaRoi (1967)
B.29 Northern Peninsula	St. Barbe South District, Nfld.	49° 30′ to 50° 50′ N 56° 40′ to 58° 20′ W	Raised bogs of coastal plain	f	Bouchard *et al.* (1978)
	Gros Morne National Park, Nfld.	49° 40′ to 50° N 57° 40′ to 58° W	Black Spruce dwarf laurel dwarf scrub	a	Bouchard and Hay (1976)
			Ericaceous dwarf scrub	a	
			Black Spruce scrub	f	
			Bog	o	
			Herbaceous communities along sea shore barrens	o	
			Balsam Fir forest	r	
B.30 Avalon	Western Bay, Nfld.	47° 50′ N 53° 10′ W	Coastal barren	f	Hall (unpublished)
	Little Catalina, Nfld.	48° 40′ N 53° 05′ W	Coastal barren	f	
B.31 Newfoundland-Labrador Barrens	St. Barbe South District, Nfld.	49° 30′ to 50° 50′ N 56° 40′ to 58° 20′ W	Alpine scrub "tuckamoor"	x	Bouchard *et al.* (1978)
			Juniper scrub on serpentine tableland	f	
	Buchans Plateau, Nfld.	48° 45′ N 57° 10′ W	Black Spruce forest	r	Bergerud (1971)
B.32 Forest tundra	Great Whale River, Quebec	55° 17′ N 77° 46′ W	Open forest with lichen or moss	f	Forest and Legault (1977)
	E. Pen Island Coast of Hudson Bay, Ontario	57° N 88° W	Bare rock on coast		
			Moss heath hummocks	r	Kershaw (1974)
			Lichen heath	r-f	Kershaw and Rouse (1973)
	Lower Hayes River, Manitoba	57° N 92° 20′ W	White Spruce forest on flood plains	f	Ritchie (1960b)
			Open White Spruce with lichen or moss scrub	f	
			Tamarack forest	o	
	Churchill, Manitoba	58° 47′ N 94° 10′ W	Black Spruce forest	a	Larsen (1972a)

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
BOREAL FOREST (continued—					
B.32 Forest tundra	Ennadai Lake, N.W.T.	60° 42′ to 61° 10′ N 100° 55′ to 101° 45′ W	Black Spruce forest	a	
			White Spruce forest	a	
			Tussock muskeg tundra	a	
			Rock field	a	
	Artillery Lake, N.W.T.	63° 05′ N 108° 05′ W	Black Spruce forest	a	
			White Spruce forest	a	
			Tussock muskeg tundra	a	
			Rock field	a	
	Campbell-Dolomite Uplands, N.W.T.	68° 20′ N 133° 40′ W	Open Black Spruce woodland	o	Ritchie (1977)
			Black Spruce forest	o	
	Inuvik, N.W.T.	68° 23′ N 133° 42′ W	*Picea mariana-Vaccinium uliginosum* woodland	r-a	Black and Bliss (1978)
B.33 Alpine Forest Tundra	Nahoni (1200 m) and Ogilvie (1350 m) Uplands, N.W.T.	65° 36′ N 136° 41′ W 64° 18′ N 137° 21′ W	Alpine lichen communities	r-o	See and Bliss (1980)
MONTANE					
M.5 Douglas-fir and Lodgepole pine	Banff and Jasper National Parks, Alberta (1280-1830 m)	50° 55′ to 53° 10′ N 115° to 119° W	Lodgepole Pine-lichen woodland forest	r	
			Lodgepole Pine forest	r	
Alpine tundra	Jasper National Park, Signal Mt. (2180-2260 m)	52° 51′ N 117° 59′ W	Dryas rock tundra	r	Hrapko and LaRoi (1978)
			Heath tundra	r-o	
			Sedge-wood rush snow bed tundra	r	
COASTAL FOREST					
C.3 Northern Pacific Coast	Pacific Rim National Park, Vancouver Island, B.C.	49° 10′ N 125° 55′ W	Sphagnum bog	r	Pojar (1974)
GREAT LAKES-ST. LAWRENCE FOREST					
L.6 Temiscouata-Restigouche	Bic and Gaspé Peninsula, Quebec	48° to 49° 15′ N 64° 15′ to 68° W	Slaty sea ledges and sea cliffs	x	Scoggan (1950)
L.12 Rainey River	Southeastern Manitoba	49° 00′ to 49° 40′ N 95° 10′ to 96° 20′ W	Jack Pine forest	o	Mueller-Bombois (1964)
			Black Spruce-feather moss forest	f	
			Deciduous forest (Trembling Aspen, Balsam, Poplar)	r	
			Jack Pine-deciduous forest	r	
			Tamarack-White Birch forest	r	

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
USA HEMLOCK-WHITE PINE NORTHERN HARDWOODS					
N. Appalachian Highlands	Presidential Range, New Hampshire	44° 15′ N 71° 20′ W	Dwarf shrub heath with sedge & rush	o-f	Bliss (1963)
			Dwarf shrub heath	o	
			Diapensia	r	
			Bog	r	
Great Lakes-St. Lawrence	Lake Agassiz peatlands, Minnesota	48° 05′ N 92° 45′ W	Mixed swamp forest	r	Heinselman (1970)
			Cedar string bog and fen	r	
			Tamarack string bog and fen	r	
			Black Spruce-feather moss forest	r	
			Sphagnum-Black Spruce-Leather Leaf bog forest	r	
			Sphagnum-Leather Leaf-laurel-spruce heath	r	
LOW ARCTIC TUNDRA					
New Quebec	Port Burnell, N.E. coast of Ungava Bay, Quebec	60° 25′ N 64° 52′ W	Dwarf scrub heath on lowlands	o-d	Polunin (1948)
	Wakeham Bay, S. Shore of Hudson Strait, Quebec	61° 36′ N 71° 57′ W	Lichen heath on lowlands	a	
			Herbaceous tussocks in marsh areas	f	
			Dwarf scrub heath on lowlands	f-a	
			Dwarf scrub heath, snow patches	f	
	Puvirnitug, Quebec	60° 02′ N 77° 15′ W	Communities on shores and dry gravel	x	Bournérias (1971)
South Coast of Baffin Island	Lake Harbor	62° 52′ N 69° 53′ W	Dwarf scrub heath on lowlands	f	Polunin (1948)
			Dwarf scrub heath on summits and slopes	o	
			Birch-willow dwarf scrub	f	
	Cape Dorset	64° 10′ N 76° 30′ W	Herbaceous communities on south facing slopes	f	
			Dwarf scrub heath on lowlands	f-a	
Western Coast of Hudson Bay	Coral Harbor, Southampton Island	64° 08′ N 83° 10′ W	Dwarf scrub heath	f	
	Chesterfield Inlet	63° 20′ N 90° 42′ W	Dwarf scrub heath	a	
			Dwarf scrub heath, snow patches	f	

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
LOW ARCTIC TUNDRA (continued)					
Keewatin District	Northern Keewatin, N.W.T.	64° to 69° N	Sedge meadow	r	Thompson (1980)
			Willow-sedge meadow	r	
		91° to 98° W	Orthophyll scrub	r	
			Lichen-heath plateau	r	
			Lichen uplands	r	
			Barrens	r	
	Snow Bunting Lake, N.W.T.	66° 10′ N 94° 25′ W	Low meadow	o	Larsen (1972b)
			Rock field	f	
			Scattered lichens on esker summits	f	
	Pelly Lake, N.W.T.	66° 03′ N	Wet Cotton Grass meadow	o	
		101° 03′ W	Dry lichen heath	a	
			Dwarf scrub-herb tundra	o	
			Rock field	a	
	Dubawnt Lake N.W.T.	64° 01′ N 99° 25′ W	Black Spruce forest	o	
			Tussock muskeg tundra	a	
			Rock field	a	
Mackenzie District Eastern Area	Clinton Colden Lake, N.W.T.	64° 08′ N 107° 27′ W	Dwarf scrub	a	Larsen (1971a)
			Tussock muskeg tundra	a	
			Rock field	a	
	Matthews Lake, N.W.T.	64° 05′ N 111° 15′ W	Marshy hummocks	a	Cody and Chilcott (1955)
Mackenzie Delta and Tuktoyaktuk Peninsula	Various sites	68° 45′ to 69° 55′ N	Dwarf scrub heath	r-a	Corns (1974)
			Medium scrub heath	r-a	
		131° 20′ to 134° 40′ W	Dwarf Birch on raised center polygons	r-a	
			Sedge heath and sedge-Cottongrass heath	r-f	
			Sedge meadow	r-f	
	Various sites	68° 20′ to 69° 55′ N 131° 20′ to 134° 45′ W	Dwarf scrub heath	f	Hernandez (1973)
			Cottongrass dwarf birch heath	f	
		69° N 131° 52′ W	Black Spruce forest-tundra	f	Ritchie (1974)
			White Spruce-birch forest	f	
		69° 10′ N 133° 10′ W	Cottongrass-lichen	f	
	Tuktoyaktuk	69° 27′ N 133° W	Dwarf shrub heath	a	Haag (1974)
	Tuktoyaktuk		Dwarf shrub heath	f-a	Wein and Bliss (1973)
ALASKA, USA INTERIOR FOREST					
	Eastern Alaska Yukon-Tanana Upland (390 m)	63° 42′ N 144° 23′ W	Black Spruce forest	a	LaRoi (1967)

TABLE 1. *(continued)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
ALASKA, USA					
INTERIOR FOREST (continued)					
	Eastern Alaska Yukon-Tanana Upland (600 m)	62° 06′ N 145° 52′ W	Black Spruce forest	a	
	(345 m)	65° 15′ N 146° 47′ W	White Spruce-fir forest	r	LaRoi (1967)
	(600 m)	63° 33′ N 148° 48′ W	White Spruce-fir forest	a	
	(705 m)	61° 59′ N 146° 53′ W	White Spruce-fir forest	a	
	Near Fairbanks	64° 80′ N 148° 06′ W	Open Black Spruce forest with feather-moss and lichen	f	Dyrness & Grigal (1979)
			Closed Black Spruce forest with feather-moss	f	
			Open Black Spruce woodland with moss and lichen	f-a	
			White Spruce forest with alder	f-a	
	Sites near Fairbanks	65° N 147° W 65° N 148° W	Black Spruce forest	r-f	
	National Moose Range, Kenai Peninsula	58° to 62° N 150° to 151° W	Mature spruce-deciduous forest	f-d	Oldemeyer and Seemel (1976)
			Mature deciduous forest (Trembling Aspen, White Birch)	d	
			Spruce regrowth after 1947 fire	f-d	
			Birch-spruce regrowth after 1947 fire	f-d	
COASTAL FOREST					
	Glacier Bay, S.W. Alaska (5-45 m)	58° 22′ N 135° 37′ W	Hemlock-spruce forest	r	Reiners *et al.* (1971)
			Lodgepole Pine muskeg	r	
LOW ARCTIC TUNDRA					
	Upper Firth River Valley, Alaska-Canada	69° N 141° W	Dwarf scrub-herbaceous communities on centers of frost polygons	x	Drew and Shanks (1965)
			String fen and bog	x	
			Sedge meadow	x	
	Umiat	69° 22′ N 152° 08′ W	Willow scrub	o	
			Alder scrub	r	
			Cottongrass-dwarf scrub heath	f	
			Sedge-dwarf shrub heath	f	

TABLE 1. *(concluded)*

Vegetation region* section	Location and elevation (m)	Latitude and longitude	Plant community	Relative abundance of *V. vitis-idaea* var. *minus*	Reference
LOW ARCTIC TUNDRA (continued)					
	Ogotoruk Valley	68°06′ N 165°46′ W	Cottongrass tussock tundra	o	
	Cape Thompson region	65°45′ to 69°00′ N	Wet herbaceous meadows	r	Johnson *et al.* (1966)
		162°00′ to 166°15′ W	Cottongrass tussocks on soilifluctia slopes and with ice-wedge polygons	o	
			Sedge communities of high center polygons	o	
			Meadows on dry rocky uplands	r	

*Vegetation Regions in Canada after Rowe (1972), Alaska after Viereck and Little (1975), and the conterminous United States after Braun (1950). Low arctic climate designation after Bliss (1979).

Jay Peak, Vermont, a sub-alpine site had a leaf surface-to-biomass ratio of 51 ± 9 cm^2/g (Svoboda and Taylor 1979). In Norwegian birch forest, this ratio for *V. vitis-idaea* was 96 cm^2/g dry wt. on 18 June, attained its maximum of 211 cm^2/g dry wt. on 20 July and fell to 121 cm^2/g dry wt. by the end of August (Berg *et al.* 1975). Most of the leaves were held at angles of less than 30° from the horizontal.

(b) Physiology. Chlorophyll content of *Vaccinium vitis-idaea* var. *minus* in tundra associations at Tuktoyaktuk (Hutchinson *et al.* 1976) was 11.0 μg/leaf on 15 July 1973, rose to 18.4 μg/leaf by 20 August but dropped to 9.5 μg/leaf by 31 August. Plants contained 2.4 mg/g dry wt. chlorophyll α, 1.3 mg/g dry wt. chlorophyll β and 0.8 mg/g dry wt. carotenes. Total chlorophyll content in plants from a mature forest at Norman Wells was only 1.92 mg/g dry wt. in August.

Field transpiration when measured between 14.10 and 21.10 hr on 14 July 1973 had a mean value of 1.6 ± 0.6 mg H_2O/min/g dry wt./leaf. It had risen to 2.4 ± 1.2 mg H_2O/min/g dry wt./leaf when measured between 11.50 and 15.50 hr on 24 August (Hutchinson *et al.* 1976). Pigment summaries for plants affected by oil spills indicate an enhancement of pigments in regrowth after summer spills but a reduction in pigments in regrowth after winter oil spills (Hutchinson *et al.* 1976). At Hardangervidda, Norway, in a birch forest, the previous years' *V. vitis-idaea* var. *vitis-idaea* leaves were harvested on 15 and 20 July and 15 August. They yielded an average of 3.37 mg chlorophyll α and β per g dry wet.; 176 mg chlorophyll per g nitrogen; 2.06 mg chlorophyll per 100 cm^2 leaf area; the carotenoid ratio was 1.82 and nitrogen content 2.31% (Berg 1975). Data for *V. vitis-idaea* in lichen heath and dry meadow, and for older leaves are also given by Berg (1975).

The distribution of ^{14}C photosynthates (Berg *et al.* 1975) indicates that at budbreak, green parts of *V. vitis-idaea* accounted for 22% of the recovered radiocarbon in lichen heath and 39% in birch forest, while below-ground parts contained 55% in the lichen heath, and 35% in the birch forest. Two weeks after budbreak green parts accounted for 37% (lichen heath) and 49% (birch forest) and below ground parts 39% (lichen heath) and 21% (birch forest). At both sampling periods the remainder of ^{14}C was found in the non-green above-ground parts.

Hadley and Bliss (1964) studied the energy reserves of several alpine species including *V. vitis-idaea* var. *minus* on Mt. Washington. For this species they found that new shoots produced 5270 ± 24.4 cal/g and a lipid content of 3.12 ± 0.08%, quite similar to old shoots with 5288 ± 25.9 cal/g and a lipid content of 3.86 ± 0.12%. The protein content of new shoots (10.3%) was significantly higher than that of older shoots (8.7%). The calories per gram of rhizomes and roots (4996 ± 17.5) were nearly equal to those of the shoots, but the lipid (1.43 ± 0.08%) and protein (5.3%) contents were significantly below values for the shoots. In a preliminary study Bliss (1962a) had shown that caloric values for the entire plant increased during early July but declined somewhat as the berries matured. Wielgolaski and Kjelvik (1975) give caloric values for *V. vitis-idaea* in

TABLE 2. *Vaccinium vitis-idaea* L. var. *minus* Lodd. and associated species in nine representative plant communities.

	Coastal barren Bonavista, Newfoundland	Open bog Elma, Manitoba	*Picea mariana* bog Deep L., Manitoba		*Pinus banksiana* Candle L., Sask.	Tussock muskeg N. Ennadai L., N.W.T.	*Picea glauca* forest St. Elias Mts., Yukon	*Picea mariana-Sphagnum* Fairbanks, Alaska	Rockfields Pelly L., N.W.T.		*Picea mariana* open forest Inuvik, N.W.T. Stand 12.
Site	I	II	III		IV	V	VI	VII	VIII		IX
Lat.	48° 33′	49° 53′	50° 53′		53° 50′	61° 10′	61° 32′	64° 80′	66° 03′		68° 19′
Long.	53° 02′	95° 54′	100° 51′		105° 20′	100° 55′	140° 30′	148° 06′	101° 03′		133° 30′
Altitude (m)	50		650		550–700	150	1365	275–500	15–30		—
Slope (°)	varied	0	0		varied	0–3	1	3–9	varied		—
Aspect	—	—	W		varied	—	S	SE	—		—
Bare ground %	1	—	—		—	—	0	—	—		—
Shrubs and Herbs △	C%	RF%	C%	F%	F%	F%	C*	C%	F%	C%	F%
Vaccinium vitis-idaea var. *minus*	20	8	4	69	59	94	4	22	81	22	100
V. angustifolium	23					20					
Empetrum nigrum	15					65	5		57	1	24
Kalmia angustifolia	10	6									
Ledum groenlandicum	5	13	32	94	23	2		29		1	44
Potentilla tridentata	2				6						
Chamaedaphne calyculata		19	1	1							
Oxycoccus quadripetalus		10									
Gaultheria hispidula			4	56							
Corylus cornuta			6	25							
Carex disperma			12	57							
Gramineae			7	57						1	32
Smilacina trifolia			12	43							
Rubus pubescens			6	50	4						
Carex leptalea			9	50							
Linnaea borealis var. *longiflora*			8	43	66						
Oxycoccus microcarpus			2	38		10		+			
Galium triflorum			2	33							
Moneses uniflora			1	29							
Circaea alpina			1	17							
Mitella nuda			1	14	5						
Vaccinium myrtilloides					49						
Cornus canadensis					49			+			
Maianthemum canadense					33						

Elymus innovatus	33						
Rosa acicularis	25						
Equisetum scirpoides	22		3				+
Fragaria virginiana	19						
Arctostaphylos uva-ursi	18		1				
Petasites palmatus	12						
Pyrola secunda	11						
Trientalis borealis	11						
Oryzopsis pungens	10						
Lathyrus ochroleucus	9						
Galium boreale	9						
Epilobium angustifolium	7						
Viola canadensis	7						
Viburnum edule	6						
Alnus crispa	5						+
Disporum trachycarpum	4						
Aralia nudicaulis	4						
Pyrola asarifolia	4						
Melampyrum lineare	4						
Pyrola virens	3						
Picea glauca			5				
Calamagrostis canadensis	3			20			
Arctostaphylos alpina				4			
Ledum palustre		90	5	4	89	27	100
Rubus chamaemorus		81		8		1	32
Vaccinium uliginosum		58	6	5	13	+	16
Andromeda polifolia		39					
Carex rotundata		95					
Eriophorum vaginatum ssp. *spissum*		21		1		17	40
Hierochloë alpina					68		
Carex sp./spp.					65		
Cassiope tetragona					27		
Carex bigelowii					25		
Silene acaulis					10		
Salix herbacea					9		
Salix arctica					6		
Arctagrostis latifolia					4		
Betula glandulosa		42	7	5		7	64
Salix phylicifolia ssp. *planifolia*				2			+
S. arctophila		53					
Potentilla palustris		8					
Equisetum sylvaticum				8			
Carex chordorrhiza		18					
Salix glauca ssp. *acutifolia*			4				+
Pedicularis labradorica			3				
Saussurea angustifolia			2				+

TABLE 2 *(continued)*

	Coastal barren Bonavista, Newfoundland	Open bog Elma, Manitoba	*Picea mariana* bog Deep L., Manitoba		*Pinus banksiana* Candle L., Sask.	Tussock muskeg N. Ennadai L., N.W.T.	*Picea glauca* forest St. Elias Mts., Yukon	*Picea mariana-Sphagnum* Fairbanks, Alaska	Rockfields Pelly L., N.W.T.		*Picea mariana* open forest Inuvik, N.W.T. Stand 12.
Site	I	II	III		IV	V	VI	VII	VIII		IX
Lat.	48°33′	49°53′	50°53′		53°50′	61°10′	61°32′	64°80′	66°03′		68°19′
Long.	53°02′	95°54′	100°51′		105°20′	100°55′	140°30′	148°06′	101°03′		133°30′
Altitude (m)	50		650		550–700	150	1365	275–500	15–30		—
Slope (°)	varied	0	0		varied	0–3	1	3–9	varied		—
Aspect	—	—	W		varied	—	S	SE	—		—
Bare ground %	1	—	—		—	—	0	—	—		—
Shrubs and Herbs △	C%	RF%	C%	F%	F%	F%	C*	C%	F%	C%	F%
Pyrola grandiflora							2				
Mosses											
Polytrichum juniperinum		15					1	4		+	12
Sphagnum fuscum		14	13	14						1	8
Aulacomnium palustre		5	2	14							
Pleurozium schreberi			29	57				29			
Hylocomium splendens			9	29			4	2			+
Mnium sp.			2	29							
Ptilium crista-castrensis			2	14							
Helodium blandowii			1	14							
Aulacomnium acuminatum										2	24
A. turgidum										5	60
Dicranum angustum										3	32
D. undulatum										2	12
D. fuscescens							1			1	84
Sphagnum spp.								48		17	40
Brachythecium spp.										+	16
Eurynchium pulchellum											
Rhytidium rugosum							3			1	32
Bryum pseudotriquetrum										+	26
Sphagnum sp. & *Cladina rangiferina*	24										
Hypnum revolutum										1	24
Dicranum elongatum										2	12
D. muelhlenbeckii							2				

Aulacomnium palustre		2				
Rhacomitrium sp.				15		
Moss species	90			86	43	96
Liverwort					6	84
Lichens						
Lichen species	70			100	12	80
Cladonia spp.			16		2	44
C. arbuscula		3		100	12	80
C. amaurocraea		3				
C. alpestris						
Peltigera polydactyla		3				
P. aphthosa		2	+		+	12
P. canina			4			
Cladina mitis					12	84
C. rangiferina					12	40
Cetraria nivalis		2		22	1	12
C. islandica				1	12	
C. cucullata				22	3	84
Stereocaulon tomentosum		4				
Alectoria nitidula				25		
A. ochroleucha				66		

Additional species not in Table.

III Shay and Shay (1979)
- *Ribes glandulosum*
- *Andromeda glaucophylla*
- *Picea mariana*
- *Larix laricina*
- *Abies balsamea*
- *Drosera rotundifolia*
- *Habeneria obtusata*
- *Listera cordata*
- *Coptis trifolia*
- *Rubus acaulis*
- *Tomenthypnum nitens*

IV Swan and Six (1966)
- *Lycopodium complanatum*
- *Geocaulon lividum*
- *Schizachne purpurascens*
- *Aster ciliolatus*
- *Oryzopsis asperifolia*
- *Vicia americana*

V Larsen (1965)
- *Pedicularis labradorica*
- *Pinguicula villosa*
- *Carex capillaris*
- *C. stans*
- *Eriophorum angustifolium*
- *Picea mariana*
- *Loiseleuria procumbens*

VI Birks (1977)
- *Dryas integrifolia*
- *Carex concinna*
- *Cladonia pyxidata*
- *Pohlia nutans*
- *Dicranella heteromalla*

VII Dyrness and Grigal (1979)
- *Nephroma arcticum*

VIII Larsen (1973)
- *Luzula confusa*
- *Stellaria longipes*
- *Poa* spp.
- *Salix brachycarpa* var *niphoclada*

IX Black and Bliss (1978)
- *Astragalus alpinus*
- *Equisetum arvense*
- *Arctagrostis latifolia*
- *Ptilidium ciliare*
- *Tomenthypnum nitens*
- *Drepanocladus* spp.

TABLE 2 *(continued)*

Footnotes for Table

I — Hall (1979); II — Reader and Stewart (1971); III — Shay and Shay (1979); IV — Swan and Dix (1966); V — Larsen (1965); VI — Birks (1977); VII — Dryness and Grigal (1979); IX — Black and Bliss (1978).

Sample size Site: 1, 100 points along a 100 m transect;
II, 50 random points;
III, 14–0.25 m^2;
IV, 30–0.25 m^2;
V, 180–1 m^2;
VI, 16 m^2 plot;
VII, 48–25 m^2 plots;
VIII, 20–1 m^2;
IX, 25–0.1 m^2.

C% — percent cover; F% — percent frequency; RF% — relative frequency %; C* — cover Domin 1-10 scale; species included have F% $\geqslant$ 3%, C% $\geqslant$ 2%, + cover $>$ 2% for species already listed in another site.

Δ Nomenclature follows Scoggan (1979), original authors slightly modified.

V Nomenclature follows original authors.

Norwegian tundra dry meadow sites as 4895 ± 25 calories per g dry wt. for green material, 4734 ± 32 for non-green material above the roots, 4731 ± 52 for living roots and 4634 ± 83 for dead material.

The light compensation point for this species on Mt. Washington was 200 ftc and the light saturation point 2000 ftc. Following the cessation of terminal shoot growth, respiration decreased with a resulting increase in net photosynthesis (Hadley and Bliss 1964). *Vaccinium vitis-idaea* was one of the species selected for detailed physiological study in Norway. Nygaard (1975) reports the effects of low temperature pretreatment (8-12 hr at +2–3° C and 12-16 hr at +10° C) and high temperature pretreatment (8-12 hr at +15° C and 12-16 hr at +23–25° C) at a relative humidity of 80% using an infrared gas analyzer. The apparent photosynthesis in *V. vitis-idaea* pretreated at high temperatures was higher than when pretreated at low temperatures. For example with high temperature pretreatment apparent photosynthesis at 15° C was 4.2 mg CO_2/g/hr and with low temperature pretreatment photosynthesis at 15° C was 2.1 mg CO_2/g/hr (see Nygaard 1975, p. 165). Such acclimation effects were smaller in experiments carried out in summer than in fall. The CO_2 compensation point as a function of acclimation temperature was 63 ppm at 25° C in low temperature material, 51 ppm at 25° C for high temperature material, and 86 ppm for untreated material.

Skre (1975) reports CO_2 exchange data for *V. vitis-idaea* under different experimental conditions and compares his Norwegian data with other studies. The values for apparent photosynthesis of 5-6.7 mg CO_2/g/hr are higher than those of Hadley and Bliss (1964) and Scott and Billings (1964) but agree with those of Nygaard (1975).

The composition of stems and leaves of *V. vitis-idaea* var. *minus* was monitored at various seasons on the Kenai Peninsula, Alaska (LeResche and Davis 1973, Oldemeyer and Seemel 1976, Oldemeyer *et al.* 1977). Their data indicate a slight protein peak in summer (Table 3) also shown by Scotter (1965) in northern Saskatchewan. However there was a dramatic decrease from summer to winter in values for Ca, Mg, K, Na, Cu, Fe, Mg, Zn and Mn.

In the test garden at Kentville, Nova Scotia, the levels of various elements found in *V. vitis-idaea* var. *minus* are similar to those given by Gerloff *et al.* (1964) for several other ericaceous species. At Kentville, levels of N and P in current leaves (Table 4) were greatest in June and decreased to September. Calcium in the current growth increased as the season progressed undoubtedly due to the buildup of calcium pectate in the cell walls of the leaf tissue. Similar trends were previously reported for *Vaccinium angustifolium* (Townsend *et al.* 1968). The

TABLE 3. Composition of stems and leaves of *V. vitis-idaea* L. var. *minus* Lodd. from northern Saskatchewan and the Kenai Peninsula, Alaska.

	Scotter* 1965			LeResche and Davis 1973	Oldemeyer and Seemel 1976		Oldemeyer *et al.* 1977
	July 1960	Sept. 1960	Mar. 1961	3 analyses May 1971	3 sites Aug. 1973	6 sites Feb. 1974	6 sites July 1974
Carbohydrate %							
Cell walls				67	33.1 ± 1.26	37.7 ± 1.89	50.5
Acid detergent fibre				17.6	29.3 ± 1.41	31.9 ± 2.00	44.6
Lignin				50.0	12.6 ± 1.04	13.2 ± 1.62	23.8
Protein %	6.33	7.87	6.34	5.4	5.7 ± 0.42	5.4 ± 0.30	7.6
Minerals ppm							
Ca	4700	5500	5500	6300	4920 ± 545.28	26.7 ± 3.23	699
Mg	-	-	-	1700	1328 ± 273.60	4.6 ± 0.41	1426
K	-	-	-	3400	438 ± 288.68	29.8 ± 5.94	3691
Na	-	-	-	80	55 ± 13.23	22.8 ± 0.41	72
Cu	-	-	-	-	5.9 ± 3.82	0.2 ± 0.03	13.8
Fe	-	-	-	-	51.3 ± 19.86	3.2 ± 0.88	44
Zn	-	-	-	-	8.3 ± 3.82	0.3 ± 0.32	8.6
Mn	-	-	-	-	17.6 ± 3.62	1.9 ± 0.29	111.8
P	1000	1600	1100	900	- -	- -	-
Ether extract %	-	-	-	2.1	- -	- -	-
Ash %	2.32	2.71	2.25	2.1	- -	- -	-
Crude fat %	2.81	2.81	3.16	-	- -	- -	-
fibre %	15.63	20.37	17.70	-	- -	- -	-

*Northern Saskatchewan, leaves only were analysed.

TABLE 4. Nutrient levels in *Vaccinium vitis-idaea* L. var. *minus* Lodd leaves from the test garden at Kentville, Nova Scotia

Leaf cohort	Date	% composition on dry wt. basis N	P	K	Mg	Ca
pyg[1]	2 June 79	0.87[2]	0.060	0.27	0.12	0.61
c	2 June 79	1.43	0.145	0.58	0.12	0.29
pyg	5 July 79	0.81	0.067	0.42	0.13	0.55
c	5 July 79	0.92	0.103	0.59	0.14	0.39
pyg	2 Aug 79	0.70	0.060	0.32	0.16	0.52
c	2 Aug 79	0.85	0.095	0.38	0.13	0.41
pyg	5 Sept 79	0.76	0.072	0.43	0.15	0.61
c	5 Sept 79	0.87	0.093	0.48	0.15	0.50

1. pyg = preceding year's growth, c = current growth.
2. samples dried at 70° C and analysed by standard procedures (A.O.A.C. 1970).

decline of N content in the previous year's leaves during the early summer suggests that senescence has commenced. Levels of N, P and K were higher in the current leaves than the preceding year's at all dates, whereas with Ca, the preceding year's leaves had the higher values. For Mg, values were more or less equal for the two years at the various sampling dates. The unfertilized soil producing the leaves sampled (Table 4) was a well drained Berwick sandy loam with a pH of 4.6 (Cann *et al.* 1965).

Analysis of mineral content of *V. vitis-idaea* in IBP tundra sites in Norway and Finland is given in Wielgolaski *et al.* (1975). In general the data are similar to the Kentville analyses.

Stark *et al.* (1979) have shown that ripe fruit has a high tannin content (721 mg/100 g fresh weight), high anthocyanin content (127 mg/100 g), low pH (2.5) and a total sugar content of 6.6%. Hoffman *et al.* (1967) found the ascorbic acid of *V. vitis-idaea* var. *minus* on 15 September was 22.5 mg/100 g and the β-carotene on 23 September 1964 was 0.79 μg/g of berries.

(c) Phenology. Bell and Burchill (1955) found that *V. vitis-idaea* var. *minus* overwintered with ovule development barely evident and sporogenous tissue present in some flowers. According to these authors it was the 12th ericaceous species to bloom in Nova Scotia, from mid-June to early July. A major difference between *V. vitis-idaea* var. *minus* and its European counterpart var. *vitis-idaea* is the fact that the latter had two flowering periods per season (Ritchie 1955). On 15 May 1979 vegetative growth measured 1 cm on plants in the transplant garden at Kentville (lat. 45° 04'N) and full bloom occurred on 25 May. This was an unusually early season, approximately two weeks early. With plants further north the date is later, blooming in the Yukon about mid-July. The first flowering of this species at Sheep Mountain, southwest Yukon, (lat. 61° 21'N) occurred about 1 July and continued for nearly a week; it was the 48th of 60 species to flower (Hoefs 1979). On Mt. Washington (lat. 44° 17'N), Hadley and Bliss (1964) reported that vegetative growth started 18 June, plants were in flower on 2 July, and bore young fruits by 25 July. Ritchie (1955) states that root growth occurs in both early spring and fall in *V. vitis-idaea* var. *vitis-idaea*. Old leaves of var. *minus* were starting to drop in August of the second year in Nova Scotia. Svoboda and Taylor (1979) indicated that leaves persist for 3 years. *Vaccinium vitis-idaea* shoots began to grow from 23-30 June in a Norwegian alpine heath 200-300 m above tree line (Wielgolaski and Karenlampi 1975), the time of snowmelt being a very important feature that varies from year to year. Growth in Finland begins about 20 days after snowmelt (Kjelvik and Karenlampi 1975) and lasts about 40 days. There is a shorter period between snowmelt and budbreak in Norway and length growth ends about 25 July in Norwegian birch forest and lichen heath. The delay in budbreak may be a form of protection for plants growing on exposed sites with thin, early melting snow cover (Wielgolaski and Karenlampi 1975). In Norwegian alpine lichen heath, shoot growth of *V. vitis-idaea* was 7 mm in 1971 and almost the same in the warmer summer of 1972. It grew about 10 mm in a dry alpine meadow in both years, while in subalpine birch forest it grew 39 mm in 1971 and 42 mm in 1973, appearing to be strongly dependent on moisture (Wielgolaski and Karenlampi 1975). Maximum shoot length was attained in early July in the subalpine birch forest, and toward the end of July in the alpine lichen heath. *Vaccinium vitis-idaea* in the birch forest had a higher fertility (3.2%) than in lichen heath sites (0.6%) and dry meadow (0%).

7. *Reproduction*

(a) Floral biology. Vaccinium vitis-idaea is slightly protandrous, that is, the anthers ripen and release their pollen before the stigma of the same flower is receptive but is partially self-compatible. It produces both odors

and nectar (Pojar 1974). In Newfoundland cross pollination is by bees and butterflies (Torrey 1914), while in southern B.C. it is pollinated by bumble bees and bee flies (Pojar 1974). Warming (1908) lists four bumble bees: *Bombus balteatus, B. consobrinus, B. lapponicus* and *B. jonellus* as the chief pollinators in Greenland. Torrey (1914) states that under field conditions in southeastern Newfoundland flowers remain open for about a week and that under favorable conditions, 30% of the pollinated flowers set fruit. Flowers that were cross-pollinated between clones set fruit more readily than selfed flowers (Hall and Beil 1970). A significant positive correlation ($r = 0.466$) was found between seed number and berry weight (Hall and Butler 1971). Two nectar samples from 50 blossoms collected on 26 May 1979 yielded 1.0 and 1.6% soluble solids.

(b) Seed production and dispersal. Seventy-five berries collected on Tancook Island, Nova Scotia in October 1978 were stored at 1° C until 21 March 1979, when their mean weight was 0.403 ± 0.098 g and the mean number of seeds was 15.2 ± 7.4. In contrast, an average of 6.7 seeds per berry was reported for var. *vitis-idaea* in Britain where seed set and berry production followed pollination by 2-4 weeks (Ritchie 1955).

Data from a stand of *V. vitis-idaea* var. *minus* on Tancook Island, Nova Scotia, show that the weight of sterile shoots was not significantly greater than that of fruiting shoots (without berries) and the weight of berries exceeded 1000 kg/ha. The weight of 25 immature berries (0.15 ± 0.01 g) taken on 25 July 1979 from the same locality was considerably less (berries will increase in weight by at least one-third in final month of growth) than that of mature berries reported above. Veijalainen (1976) reports the average yield of *V. vitis-idaea* in a good uncultivated site in Finland to be 500 kg/ha and the maximum yield in cultivation to be 8150 kg/ha. The yield from a fertilized forest was 3000 kg/ha.

Seeds are dispersed in the droppings of many birds and mammals, such as *Dendragapus obscurus* (Grouse), *Calachites canadensis* (Spruce Grouse), *Piranga erythromelas* (Scarlet Tanager), *Sialia sialis* (Eastern Bluebird), *Hylocichla* spp. (Thrushes), and other songbirds, as well as *Ursus americanus* (Black Bear), *Tamias striatus* (Eastern Chipmunk), *Peromyscus leucopus* (White-footed Mouse) and other mammals (Martin *et al.* 1961).

(c) Seed viability and germination. Seeds were collected from 13 sites in eastern Newfoundland on 13 and 14 September 1977 and held in a refrigerator at 1° C until 20 December when germination tests began. Seeds placed on the surface of a peat-vermiculite medium under 16 h light at 26° C and 8 h dark at 24° C had 87% germination after 59 days. The highest rate of germination was in seeds extracted from fresh, mature berries and a steady decline occurred with less than 10% germinating by 12 to 16 months. Johnson (1975) studied buried seeds in a subarctic lichen woodland east of Great Slave Lake, and reported that 65% of the sample cores contained seed of *Vaccinium vitis-idaea* and *V. uliginosum*. *Vaccinium vitis-idaea* counts showed 3.3 seeds/1000 cc of which 0.7 seeds/1000 cc were fertile at Porter Lake (180 years post-fire), and 4.8 seeds/1000 cc with zero fertility as Selwyn Lake (98 years post-fire). In Britain, Ritchie (1955) reports a lower percentage seed germination for freshly harvested seeds but an increased rate for cold-treated seeds.

(d) Vegetative reproduction. Examination of ericaceous communities in the Atlantic Provinces and Quebec suggests that lateral growth is by rhizome proliferation of ramets from the original seed-established clones (Hall and Beil 1970). Harper and White (1974) report a similar situation in *V. myrtillus*. Large old clonal plants may eventually break up by frost action, fire, burrowing, etc. into separate clones which, in turn, produce their own vegetative shoots and rhizomes. Pojar (1974) reports vegetative reproduction by creeping stems, and Johnson and Rowe (1977) indicate that this is an efficient means of vegetative reproduction in subarctic habitats.

Eighty-two percent of the stem cuttings from 14 Newfoundland clones produced roots, when held under intermittent mist, from 15 September 1977 to 7 December 1977. Studies in Finland on propagation have shown that rooting of stem cuttings is best in the spring (89%). Milled peat (85%) is superior to humus (55%) as a rooting medium; indole butyric acid at 6000 ppm gave a slight increase in rooting (90%), and pieces of rhizome behaved similarly to stem cuttings (Lehmushovi 1975). Rooting success was 83% for the controls.

8. *Population Structure and Dynamics*

(a) Dispersion patterns. Vaccinium vitis-idaea is generally dispersed contagiously, the creeping stems forming patches, but it may form mats (Hrapko and LaRoi 1978) described as loose, in moist mossy situations, or dense in dry, rocky sites (Viereck and Little 1972).

(b) Age distribution. In Sweden, Tear (1972) found that the age of plants in a woodland varied from one to nine years with the average being four. His method of determining age was based on counting the number of annual rings at the base of the aboveground stem as previously shown for *V. myrtillus* by Flower-Ellis (1971) and for *V. angustifolium — V. myrtilloides* by Hall (1957). Harper (1977) points out that shrubs are difficult for

population biology studies as the aboveground parts may be of a different age than the underground system. After any major disturbance such as a forest fire, habitat becomes available for colonisation but seedlings are subject to severe inter- and intraspecific competition from annuals in the first year, perennials (mostly sedges, grasses, legumes and composites) from years two to five and later by shrubs and trees (Torrey 1914) (see also Table 2). Once established *V. vitis-idaea* var. *minus* will persist indefinitely unless shaded out by conifers. Within 25 years after fire its frequency becomes relatively stable (Johnson and Rowe 1977).

(c) Size distribution. Ten plants which had been previously grown in 10 cm clay pots were set out in the transplant garden at Kentville in 1970. In 1979 they had an average maximum crown diameter of 70 cm. In this experiment plants grew free from competition, but under normal field conditions crown diameter would probably have been less.

(d) Growth and turnover rates. Observations in the field in Nova Scotia and Newfoundland revealed that seedlings showed high rates of survival and new crops of seedlings are produced in favorable years. Once established, plants spread by slender creeping stems rooting at nodes (Viereck and Little 1972). Fresh weight of *V. vitis-idaea* var. *minus* from Tancook Island, Nova Scotia, was 253.5 ± 69.5 g/m² for sterile shoots, 207.5 ± 43.7 g/m² for fruiting shoots and 112.5 ± 19.8 g/m² for fruit (unpublished data). Stewart and Reader (1972) reported 845 ± 8% terminal growing points per m², and 740 ± 7 rooted shoots per m² with a mean weight of 15 mg per rooted stem. Leaves contributed 27.8 g/m² (53%), flowers and fruits 13.8 g/m² (26%), new stems 8.5 g/², (16%), old stems 3.6 g/m² (5%) to the 52.7 g/m² net primary production in aerial components in a S.E. Manitoba bog. Ericoides, *Ledum groenlandicum* (Labrador-tea), *Chamaedophne calyculata* (Leather-leaf), *Kalmia polifolia* (Bog-laurel), *Oxycoccus quadripetalus* (Small cranberry) and *Vaccinium vitis-idaea* var. *minus*) had net aerial primary production of 298.2 g/m², their total annual subsurface production was 1461.1 g/m² with 1234.6 g/m² remaining after 1 year's decomposition (Stewart and Reader 1972).Thirty nine percent of the *V. vitis-idaea* leaves decomposed after 1 year in the bog. In contrast in an Alaskan site Shaver and Chapin III (1980) reported total aboveground biomass in a tussock tundra community to be 59 g/m² with above ground productivity being 16 g/m²/yr. Leaves accounted for 35.4 ± 8.8 g/m²., stems 18.3 ± 3.3 g/m², and 2.4 ± 0.1 g/m² occurred in the unstructured organic layer (Shaver and Cuttler 1979). *Vaccinium vitis-idaea* var. *minus* accounted for 22% of the average 2 year production. The mean annual aerial production at four sites near Inuvik, Alaska (Wein and Bliss 1973a) was 6.1 g/m² with new leaf growth appearing in mid-July. Productivity in the Kenai peninsula, Alaska, ranged from 1000-3000 kg/ha (Oldemeyer and Seemel 1976). Data for productivity in various Fennoscandian communities is given in Kjelvik and Karenlampi (1975). Leaves persist for at least 3 years.

(e) Successional role. Seeds can germinate on bare ground if conditions are favorable, but *V. vitis-idaea* var. *minus* is not generally a pioneer species, although it grows on the summits of the highest rockfields at Pelly Lake, N.W.T. with *Rhododendron lapponicum* (Lapland Rosebay), *Hierochloë alpina* (Holy Grass), *Alectoria ochroleuca* (Lichen) and *A. nitidula* (Larsen 1972b). It invades the nearby tundra bog gravel communities dominated by *Alectoria ochroleuca, A. nitidula, Hierochloë alpina* and *Luzula confusa* (Woodrush). It also invades senescent *Eriophorum vaginatum* (Cotton-grass) tussocks in communities dominated by the *Eriophorum* and areas of frost activity after the pioneers (Larsen 1972b). It combines the *Empetrum nigrum* and a lichen mat to form a seral community leading towards White Spruce (Ritchie 1959). Mueller-Dombois (1964) reports it in successionally advanced Jack Pine stands with 2-5 cm humus and rotten wood on the ground.

In the far north *V. vitis-idaea* var. *minus* assumes a climax role (Cody 1954a) whereas in the barrens of Newfoundland it acts as a seral species before being displaced by *Picea mariana* (Black Spruce) and *Abies balsamea* (Balsam Fir).

9. *Interaction with Other Species*

(a) Competition. Since light intensities below 2152 lux are limiting (Hadley and Bliss 1964), *Picea glauca* (White Spruce), *P. mariana,* and *Abies balsamea* must be considered serious competitors for light. Similarly *Kalmia angustifolia* (Sheep-laurel), *Ledum groenlandicum* and *Potentilla tridentata* (Three-toothed Cinquefoil) and other species occupying the same habitat, compete for water, nutrients, etc. (Table 2).

Of some 15 species responsible for net primary productivity of bog vegetation in southeastern Manitoba *V. vitis-idaea* var. *minus* with 7.8% relative cover is sixth in importance. Furthermore, it ranked third in total annual above-ground net production being exceeded only by *Chamaedaphne calyculata* and *Ledum groenlandicum:* respective values were 52.7, 106.1 and 68.1 g/m² (Reader and Stewart 1971). In the Mackenzie Delta between Dempster (64° N 138° W elevation 1200 m) and Umiat (69° N 151° W), sites north of the tree line and

dominated by *Eriophorum vaginatum* ssp. *spissum* had 12-31% of their cover provided by *Ledum decumbens, V. vitis-idaea, V. uliginosum* and *Betula nana* spp. *exilis. Eriophorum vaginatum, L. palustre* and *V. vitis-idaea* contributed 78-81% of the annual production (Wein and Bliss 1974).

(b) Symbiosis. Warming (1908) stated that *V. vitis-idaea* has both endotrophic and ectotrophic mycorrhiza associations. Ritchie (1955) cites additional European work which was carried out on *V. vitis-idaea* var. *vitis-idaea.*

(c) Predation and parasitism. Macoun (1884) stated that the fruit of *V. vitis-idaea* var. *minus* was invaluable as a source of food to birds migrating north in spring. Foliage of the species is eaten by a number of mammals such as *Alces alces* (Moose), *Lepus americanus* (Snowshoe Hare), *Rangifer tarandus groenlandicus* (Barren-ground Caribou), and *Ursus americanus* (Black Bear). In Alaska, Cushwa and Coady (1976) found that *Alces alces* ate large quantities of this evergreen during the winter on the Kenai Peninsula but inland, deep snow prevented consumption. In digestion trials Oldemeyer and Seemel (1976) report *in vitro* dry matter disappearance in August of this species as 50.7%. The composition of stems and leaves showed carbohydrates of cell walls to be 33.1%, acid-detergent fiber 29.3%, lignin 12.6% and protein 5.7%. In February the dry matter was lower (41.8%) carbohydrates were greater and protein about the same at 5.4%.

There is a suggestion by Kelsall (1968) that the green leaves of *V. vitis-idaea* as well as those of *Ledum groenlandicum, L. decumbens* and *Arctostaphylos uva-ursi* (Common Bearberry) may supply some special ingredient in the winter diet of *Rangifer tarandus.* In his quantitative analysis of stomach contents of caribou in northwestern Saskatchewan and District of Mackenzie he showed that *Vaccinium uliginosum* and *V. vitis-idaea* account for 3.8% of summer 21.5% of winter foods. Leaves of *V. vitis-idaea* consisted of 5.76% protein, 3.13% fat and 20.20% crude fibre. Scotter (1965) pointed out that the nutritive value of lichens was lower than that of a shrub group consisting of *Arctostaphylos uva-ursi, Ledum groenlandicum* and *Vaccinium vitis-idaea.* The group average for protein was 7.38% crude fat 3.98% and crude fibre 18.25% dry matter basis. Porsild (1962) states that species of *Vulpes* (foxes), *Lagopus* (ptarmigan), *Corvus* (ravens), *Larus* (sea gulls) and Anatidae (geese) feed on *Vaccinium* spp. fruit.

In Newfoundland, *Lepus americanus* feeds heavily on the shoots in winter and *Ursus americanus* eats this species in spring when snow has melted from the barrens but persists in the adjoining forests; *U. americanus* and *Vulpes vulpes* (Red Fox) consume quantities of the fruit in late fall and this constitutes a large proportion of their diet.

The fruit, in Newfoundland, is occasionally infested with *Grapholitha* sp. (Olethreutidae) whose larval stage generally leaves the fruit by the second week of September before fruit harvest (Hall 1978).

The major fungal diseases listed by Conners (1967) are: Red leaf — caused by *Exobasidium vaccinii,* Witches'-broom — *Pucciniastrum goeppertianum,* and leaf rust — *Pucciniastrum vaccinii.* Conners states that *E. vaccinii* occurs on *V. vitis-idaea* var. *minus* in Alaska, and Savile (1959) cites several infested specimens from British Columbia and Quebec.

(d) Toxicity and allelophathy. None Known.

10. *Evolution and Migration*

Camp (1945) placed this species in a section by itself and offered no explanation for its origin. The North American plants are consistently smaller than those in Europe (Fernald 1950). Camp (1945), however, reported that both dwarf and robust types were present in the east as well as west of this continent. Hultén (1949) states that only spp. *minus* is found in North America.

Frost and Ising (1968) used thin layer chromatography of phenolic compounds in studying *V. myrtillus, V. vitis-idaea* and the hybrid between them (*V. intermedium*). Differences in the chromatograms of the bilberries from Breanäs in southern Sweden and Värmdön near Stockholm were considerable. Between the hybrids from the localities, differences were also noted in the phenolic compounds, identified only as to position.

11. *Response Behavior*

(a) Fire. This is an important factor within the botanical range of *V. vitis-idaea* var. *minus.* In fire-prone ecosystems survival is related to the amount of moisture in the soil, the season of the year and depth of rhizome layer. In arctic *Eriophorum* tussock communities Wein and Bliss (1973a) report *V. vitis-idaea* ssp. *minus* and *E. vaginatum* ssp. *spissum* (Hare's Tail) had not recovered fully from fires after two growing seasons. The nutrient levels in leaves of *V. uliginosum* ssp. *alpinum* were higher from burned areas than unburned sites.

Vaccinium vitis-idaea var. *minus* appears within the first six years after fire rapidly attaining its maximum

and maintaining a frequency of between 70 and 100% in a range of Black Spruce-lichen, Jack Pine-lichen, and White Spruce-birch communities of all ages up to 280 years (Johnson and Rowe 1977). Black and Bliss (1978) report similar findings in *Picea mariana-Vaccinium uliginosum* forests where fire does not change plant succession as dominant vascular plants soon resprouted and achieved preburn prominence. After eight years *V. vitis-idaea* var. *minus* had a frequency of 56% and cover of 8% rising to a maximum frequency (100%) and cover (55%) at 144 years. It was the only species to increase in cover and frequency in stands aged 120-200 years, and to maintain relatively high cover values in communities 200-300 years old. It attained a cover of 15% 130 years after fire on drumlins of sand and gravel near Great Slave Lake with *Stereocaulon paschale* (22%) and *Cladonia stellaris* (17%) (Maikawa and Kershaw 1976). It dominates both burned and unburned sites in the Kenai Peninsula, Alaska (Oldemeyer *et al.* 1977).

In Eastern Canada the rhizomes of *V. vitis-idaea* var. *minus* are much finer and generally closer to the surface of the soil than those of *V. angustifolium* which can withstand regular burning (Hall *et al.* 1979). Fire, therefore, weakens the plants and reduces the proportion of *V. vitis-idaea* in mixed stands. Re-colonisation is possible by regrowth from dormant buds on stems and rhizome pieces which escape lethal temperatures.

(b) Grazing and harvesting. Small mammals such as Snowshoe Hares clip the ends of stems, destroy apical buds and cause increased branching, while Moose remove entire clusters of stems in a single mouthful. Sheep will only graze *V. vitis-idaea* when more palatable species are wanting (Ritchie 1955).

(c) Flooding. The normal habitats of this species are not subject to flooding. In peatlands, it occurs on the tops of hummocks which are drier than depressions (Larsen 1972b).

(d) Drought. Prolonged dry spells seriously reduce vegetative growth and decrease fruit size. In the drier part of its range the vigor and frequency of shoots is less.

(e) Herbicides. 2,4-D causes browning of stems and leaves, leaf drop, and at high concentrations (1.3 to 1.8 L per 450 L of H_2O) death of the plant. Relaled *Vaccinium* spp. are classified as susceptible to 2,4-D; 2,4,5-T; and intermediate to ammonium sulfamate (Ontario Weed Committee 1980).

(f) Chemical changes: oil spills. *Vaccinium vitis-idaea* var. *minus* with a frequency of 64% in a cottongrass community, and 42% in a dwarf-shrub community was sprayed with Norman Wells crude oil in July 1973 (Freedman and Hutchinson 1976). Its leaves lost their chlorophyll slowly, the dead leaves remained on plants for up to two seasons and regrowth leaves showed gigantism. A summer spill had greater effect than one in February when plants were covered by 40 cm snow because devolatisation and partial detoxification of the oil occurred before it contacted plant tissue. A year after the summer spill *V. vitis-idaea* had a frequency of 21% in the cottongrass community and 17% in the dwarf shrub community. The authors suggest that a high degree of recovery might be produced after 10 to 15 years, but species diversity would be reduced with bryophytes and lichens eliminated (Freedman and Hutchinson 1976). In mature *Picea mariana* forest, *V. vitis-idaea* had a cover of 48% and frequency of 98% prior to crude oil spills. Summer spills reduced cover to zero, while low and high intensity winter spills reduced cover to 12% and 6%, respectively. Regrowth shoots lost water more rapidly than controls, apparently due to their thinner cuticle (Hutchinson *et al.* 1976). At Tuktoyaktuk, in the cottongrass winter spill site (Hutchinson and Hellebust 1978), recovery provided up to 78% cover in the second year; 58% of this was *Eriophorum,* with *V. vitis-idaea, Calamagrostis canadensis* (Blue-joint), *Ledum groenlandicum* and *Rubus chamaemorus* (Bake-apple) providing the remainder. Hutchinson and Hellebust (1978) give flowering success and other details for *V. vitis-idaea* in cotton grass, mature forest and dwarf shrub communities after crude oil spills.

(g) Frost. Opened flowers had a 50% mortality at –1.5° C and the corresponding temperature for unripe berries and flower buds was –3.1 to –3.5° C (Teär 1972). In Japan hardening at 0° C for 10 days enhances freezing resistance in *V. vitis-idaea,* it was maximal after hardening at –3° C for 10 days when resistance to –70° C was induced (Sakai and Otsuka 1970).

12. *Relationship to Man*

Fruit of *Vaccinium vitis-idaea* var. *vitis-idaea* has been an important ingredient in the diet of most Scandinavians for centuries and harvested with small comb-sieves by hand in open woodlands. The flavor of raw berries of var. *minus* is very tart, but Porsild (1974) and Ryan (1978) claim that the flavor is improved by slight frost. Porsild (1937) states that this species is a most valuable antiscorbutic due to its high vitamin C content. Hedrick (1919) states, "This is the wi-sa-gu-mina of the Crees and the cranberry most plentiful and most used throughout Rupert's Land". In Alaska, the Inuit names are 'keepmingyuk' (Shismaref north to Noatak), 'keepmik' (Seward

Peninsula) and 'toomalgleet' (Lower Kuskokwim) and the Indian name is 'nutlut' (Heller 1953). Heller states that the berries can be mixed with rose hips to make an excellent jam. Biermann (1975) has written a brief description of the plant and suggested the economic importance of the fruit among people of Scandinavian origin in Minnesota and Wisconsin.

The berries make excellent jams, jellies, and preserves. In favorable years up to 100 tonnes are exported from Newfoundland to Scandinavian countries for human food products.

Acknowledgments

The authors acknowledge the technical assistance of A.T. Lightfoot, A.C. Brydon, K.G. Cairns and B. Brookes.

We also thank W.J. Cody, D.G. Dodds, H.J. Lloyd, J.E.H. Martin, C.T. Shay, S.P. Vander Kloet and G.W. Wood for helpful suggestions in the preparation of this manuscript and C.T. Shay for compiling Table 1.

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Revision received 5 August 1981
Accepted 23 October 1981

Notes

Observations on Black-crowned Night Heron Breeding Success in a North Dakota Marsh

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Greenwood, Raymond J. 1981 Observations on Black-crowned Night Heron breeding success in a North Dakota marsh. Canadian Field-Naturalist 95(4): 465–467.

Storms and mammalian predation severely reduced production in a Black-crowned Night Heron (*Nycticorax nycticorax*) colony in two years and drought prevented nesting in two other years from 1976 to 1980. Maximum estimated production was 2.2 young per pair in 1978, the only year production was sufficient to maintain the population.

Key Words: Black-crowned Night Heron *Nycticorax nycticorax*, productivity, marsh, weather, predation.

In the northern great plains Black-crowned Night Herons (*Nycticorax nycticorax*) commonly nest in prairie marshes (Stewart 1975; Wolford and Boag 1971) where success is influenced by factors such as predation (Eberhardt and Sargeant 1977; Greenwood 1981; Wolford and Boag 1971), unstable wetland conditions (Swanson and Meyer 1977), and violent storms (Johnson 1979; Piehl 1979). Henny (1972) assumed that the average annual recruitment rate among Black-crowned Night Herons was 2.0–2.1 young per pair, based on limited information from large east coast colonies where nests are located in trees. I found very low nesting success in a Black-crowned Night Heron colony in east-central North Dakota during 1976. The observation prompted me to return to the colony in subsequent years for additional information. The present report describes my observations for 1976–1980, and discusses some factors that influenced breeding success.

Study Area and Methods

The colony was in a 306 ha semi-permanent marsh in Griggs County, 4 km southwest of Walum, North Dakota. The area has gently rolling topography and is intensively farmed for cereal grain (Greenwood 1981). Several other large marshes are nearby. Black-crowned Night Heron nests were concentrated in a 7.5 ha clump of Phragmites (*Phragmites communis*) that was usually in standing water; water depth at the colony site ranged from 1 m in 1976 to nil in 1977. Cattail (*Typha* sp.) and Bulrush (*Scirpus* sp.) were other dominant emergent plant species in the marsh. Weather observations are from the U.S. Weather Service station at Cooperstown, North Dakota, 42 km northeast of the marsh.

I visited the colony on 30 June 1976, 1 July 1977, 29 June 1978, 12 July 1979, and 5 July 1980. On each visit nests, eggs, and young were counted; age of young was estimated by comparison with illustrations of McVaugh (1972). I attempted to determine causes and timing of mortality among dead nestlings.

Numbers of breeding pairs and production of fledged young had to be estimated because I visited the colony only once each year. Numbers of breeding pairs was based on the total number of occupied nests observed. Occupied nests contained at least one egg or nestling. All nestlings alive at time of check were assumed to fledge. Annual production per pair was estimated by dividing number of young assumed to fledge by the estimated number of breeding pairs.

Results and Discussion

Annual observations of nests and nestlings are summarized in Table 1. Nests were loosely constructed of Phragmites stems and leaves, and were elevated about 25–35 cm above water. No nests were found in 1977 or 1980. In 1977 the marsh was dry during the entire nesting period. In 1980 water depth was 0.8 m at the colony site, reflecting adequate precipitation received in 1979 (Table 2). However, very little precipitation was received in April and May 1980, and temperatures those months were above normal. I believe the dry conditions and hot weather prevented nesting.

Black-crowned Night Herons nested in 1976, 1978, and 1979, but nest success was low in 1976 and 1979. Size of largest nestlings found each year (28–36 days old) indicated that egg laying began annually in late April or early May, consistent with observations reported by Stewart (1975) and Wolford and Boag

TABLE 1. Productivity of a Black-crowned Night Heron colony in a prairie marsh in east-central North Dakota, 1976–1980.

	1976	1977	1978	1979	1980
Total nests	57	0	59	97	0
Occupied nests[a]	30	—	46	53	—
with eggs only	9	—	7	11	—
with eggs and nestlings	0	—	2	7	—
with nestlings only	20	—	37	35	—
with dead nestlings	19	—	5	30	—
with predation or scavenging	12	—	0	11	—
Total eggs	—[b]	—	22	25	—
Total nestlings	39	—	105	80	—
Live nestlings	7	—	99	30	—
Estimated fledglings/pair[c]	0.23	—	2.20	0.57	—

[a]Contain at least 1 egg or nestling.
[b]Not recorded.
[c]Total live nestlings/estimated breeding pairs (occupied nests).

TABLE 2. Mean April–June temperature and precipitation at Cooperstown, North Dakota during 1976–1980.

		Long-term mean	1976	1977	1978	1979	1980
Temp (c)	April	5.3	7.9	10.2	5.4	0.6	9.7
	May	12.1	14.1	18.9	15.6	9.5	16.0
	June	17.4	19.7	19.3	18.7	18.2	18.5
Ppt (cm)	April	3.6	3.6	1.0	3.5	8.1	0.0
	May	6.5	1.2	8.1	6.0	8.6	1.5
	June	9.7	8.7	7.1	6.8	11.3	7.9

(1971) for other colonies at northern latitudes. However, each year many broods with smaller nestlings were also present, a few as young as six days old, possibly indicating asynchrony in laying, but more likely the result of renesting after loss of initial clutches.

Adverse weather and mammalian predation were important causes of egg and nestling losses. Some nests in 1976, 1978, and 1979 were unoccupied when found, were not soiled with feces, and probably never had contained nestlings. A few of those nests may have been built by subadults. Meyerriecks, as cited by Henny (1972), stated that "many yearlings come to the nesting colonies, a few try to build nests, but I have not seen breeding by this age group." However, many unoccupied nests may have resulted from undetected predation on eggs.

Major storms on 28 June 1976, and 28 June and 3 July 1979 appeared to have influenced nesting. Prairie storms usually are accompanied by violent winds and frequently hail, and are known to kill birds (Johnson 1979; Piehl 1979). During the 1976 and 1979 visits, 82 and 63% of the nestlings observed were dead, and most appeared to have died simultaneously. In 1976 many were in the water and were just beginning to decompose, indicating recent death. In 1979 carcasses were also in the water, but were in a more advanced stage of decomposition than in 1976 (nine days had elapsed since the most recent storm). Either of the 1979 storms or both could have been responsible for the mortality. Two adult Black-crowned Night Herons also were found dead near nests in 1979, apparently victims of hail.

Of the occupied nests observed, 40% in 1976 and 21% in 1979 showed direct evidence of mammalian predation or scavenging in addition to storm damage; no such predation was observed in 1978. Evidence consisted of eggs opened by mammalian predators and partly consumed nestlings. In 1976 the partly consumed nestlings were sufficiently intact to show they died at nearly the same time as others found nearby, but I was unable to determine if they had been killed by predators or the storm. Predators responsible were probably Raccoons (*Procyon lotor*) that frequently consume carrion (Greenwood 1981), but Mink (*Mustela vison*) also inhabited the marsh. In 1976 foraging by radio-equipped Raccoons was documented in the colony on three occasions during the nesting season. An adult female foraged in the colony on the night of 16–17 June before I collected her in early morning. Stomach contents showed she had consumed 12 Black-crowned Night Heron embryos. A yearling and an adult male both foraged in the colony on the night of 29–30 June. Several partly consumed nestlings were found when I investigated the next morning. The yearling foraged in the colony again on the night of 30 June–1 July. When collected the next morning its stomach contained shell and contents of putrefied Black-crowned Night Heron eggs.

Estimated production during the five years ranged from 0 to 2.2 fledged young per breeding pair. The weighted average for the three years when nesting occurred was only 1.1 young per pair. Tremblay and Ellison (1979) found that human disturbance at Black-crowned Night Heron colonies early in the nesting season inhibited laying, but my visits were all late in the season.

Productivity estimates based on single observations are admittedly less sound than estimates derived from more intensive studies; however, only successful renesting after mid-July (highly unlikely) could have

raised my annual estimates of production substantially. Black-crowned Night Herons in North Dakota usually terminate nesting at the end of June (Stewart 1975). More precise estimates of the numbers of breeding pairs (probably higher than my minimum counts based on occupied nests) would have resulted in lower estimates of annual production than I calculated. Additional mortality among nestlings after my visits would also have lowered production estimates. The productivity I observed in all years but 1978 was far below the maintenance level of 2.0–2.1 young per pair suggested by Henny (1972). Wolford and Boag (1971) believed that the pioneering population they studied could not have maintained itself at the level of recruitment they observed. My observations suggest similar status for a small population of Black-crowned Night Herons in a North Dakota marsh.

Acknowledgments

I thank the following persons who assisted in nest counts; B. Bicknell, J. Choromanski, B. Garlinger, M. Goos, S. Hetherington, S. Evanoff, C. Lackney, L. Pellack, J. Piehl, and D. Vanderhoef. C. Faanes, D. Johnson, and A. Sargeant kindly reviewed early drafts of the manuscript, and offered many constructive comments.

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Received 19 January 1981
Accepted 19 October 1981

Historical Nest Records for the Ferruginous Hawk in Manitoba

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Bechard, Marc J. 1981. Historical nest records for the Ferruginous Hawk in Manitoba. Canadian Field-Naturalist 95(4): 467–469.

Seven previously unreported Ferruginous Hawk clutches from Manitoba have been located in museum egg collections. These together with published records clarify the hawk's past breeding history and provide stronger evidence for its disappearance from the province.

Key Words: Ferruginous Hawk *Buteo regalis,* nest records, Manitoba, population decline.

The Ferruginous Hawk (*Buteo regalis*) was once widely distributed in grassland and steppe areas of the western United States and southwest Canada (Bent 1937; Olendorff 1973; Snow 1974). Its present status is defined as "suffering from population declines and habitat diminutions in all parts of its range" (Anonymous 1979). Populations in Canada appear to have declined in areas subject to intensive agriculture and human activity (Fyfe 1976; Houston 1978). In Manitoba, cultivation has removed much of the native prairie habitat, and the Ferruginous Hawk seems to have experienced a decline (Criddle 1929; Knapton 1979). This note provides evidence for the historic breeding population and confirms the disappearance of Ferruginous Hawk in Manitoba.

Museums containing bird egg collections with egg

sets from western Canada (Kiff 1979) were contacted to obtain data on past Ferruginous Hawk nests in Manitoba. Nest records accompanying egg sets in the Western Foundation of Vertebrate Zoology and American Museum of Natural History include seven previously unreported Ferruginous Hawk nests in southern Manitoba prior to 1924. C. P. Forge, who farmed near Carman, Manitoba (Forge 1901; 1902), collected three eggs on 10 June 1907 from a nest 8.1 m above ground in an elm (*Ulmus* sp.) by the Boyne River near Hyde Park in Dufferin municipality. Hyde Park was a temporary school district (#916) three to nine miles north of present Roseisle, Manitoba. J. D. Currie found four nests with a mean of 4.0 eggs per nest on 10 May 1908 in prairie habitats of southwestern Manitoba. Perhaps because there were then few villages in that part of the province, specific locations for these nests were not given; one was reported to be in the extreme southwest corner of the province. Three were ground nests and one was built 2.0 m above ground in a willow (*Salix* sp.). On 20 May 1923, D. Ogg located a nest containing four eggs 3.8 m above ground in a balm of Gilead (*Populus tacamahacca*) and on 2 may 1924 he found a nest with four eggs 4.0 m above ground in a poplar (*Populus* sp.). Both nests were near the town of Pierson, Manitoba.

Descriptions of the construction and dung contents of all these nests indicate them to be typical of Ferruginous Hawk. As an additional check of collector identifications, I compared volumes of these eggs with those of *Buteo* species nesting in Manitoba and adjacent areas of Saskatchewan and North Dakota. Volumes were calculated using the equation of Romanoff and Romanoff (1949). Mean volumes of 77.30 (n = 20 clutches), 59.55 (n = 20), 69.35 (n = 20), and 61.26 (n = 11) ml were obtained for Ferruginous, Swainson's (*Buteo swainsoni*), Red-tailed (*Buteo jamaicensis*), and Rough-legged (*Buteo lagopus*) Hawks, respectively. Mean egg volumes of 78.05, 78.94, 73.03, 78.66, 78.12, and 76.65 ml for six of the seven clutches I am reporting were too large for any species except Ferruginous Hawk and substantiated the accuracy of collector identifications. Eggs from one of the four nests reported by J. D. Currie have been lost. Since the other egg sets he collected appear to be accurately identified, I assumed that nest also to be valid.

Before settlement, southwestern Manitoba supported mixed-grass prairie habitats interspersed with temporary and semi-permanent ponds and sloughs (Knapton 1979; Weir 1960). Trees were limited to river bottoms and "bluffs" in marshy areas. Indications are that until the 1920's the Ferruginous Hawk was not an infrequent breeding resident, nesting primarily along rivers and at the edges between prairie and forest habitats. Coues (1878) and Thompson (1891) listed the Ferruginous Hawk as a probable Manitoban, breeding in open prairie at the edge of the Pembina Mountains. Hales (1927) found it in wooded areas along the Assiniboine and Souris Rivers. W. E. Godfrey (pers. comm.) has seen, courtesy of Vere Hunt Scott of Winnipeg, two photographs of nestling hawks taken by Talbot Criddle near the family's farm at Aweme on 4 July 1917. Although labelled as Rough-legged Hawks, they are clearly identifiable as Ferruginous Hawks. Norman Criddle (1920), Talbot's brother, also reported Ferruginous Hawks to be common near Aweme in and around the Spruce Woods Timber Reserve. Those reports, with the records reported herein, indicate that the hawk nested throughout southwestern Manitoba from the Red River to the Saskatchewan border. With settlement and the spread of agriculture, the Ferruginous Hawk started a decline and by 1928 was "less common than in 1890" (Criddle 1929). Details subsequent to 1930 are not available, but failure to locate any active nests in southwestern Manitoba in the 1970's indicate that the Ferruginous Hawk has now ceased to be a breeding resident of the province (Knapton 1979). Similar Ferruginous Hawk declines have been reported in Washington, Oregon, Idaho, Utah, and North Dakota where agriculture has altered nesting habitats (Snow 1974; Stewart 1975; Powers and Craig 1976; Anonymous 1979). The decline in Manitoba also appears to be related to the loss of nesting habitat. Loss of native prairie due to invasion by forests (Bird 1961) and increased areas of cultivation may have destroyed or made unsuitable habitats, nest sites, and food supplies formerly used for Ferruginous Hawk nesting (Schmutz and Schmutz 1980).

I am grateful to C. S. Houston for suggesting this study, and for providing ideas and material concerning the historical geography and biography, with the help of Peter Bower and Barry Hyman of the Public Archives of Manitoba. Lloyd Kiff assisted in locating pertinent egg sets and data in the Western Foundation of Vertebrate Zoology. W. E. Godfrey contributed the Talbot Criddle nest record and R. W. Nero provided constructive criticism. John Bull of the American Museum of Natural History is acknowledged for his help with nest records.

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Received 3 April 1981
Accepted 4 September 1981

Nesting of Smith's Longspurs in British Columbia

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In 1979 and 1980, 7 nests of Smith's Longspurs were found in the Chilkat Pass area, the first confirmed breeding records in British Columbia.

Key Words: Smith's Longspur, *Calcarius pictus*, breeding range, British Columbia.

Smith's Longspurs (*Calcarius pictus*) nest in grassy and hummocky tundra from Alaska (Kessel and Gibson 1978), east across the Yukon and Northwest Territories, to the northwest border of Hudson Bay (Godfrey 1966). There is limited information on the southern extent of their breeding range in Alaska (Sage 1976) and indirect evidence for the southern Yukon (Hoefs 1973). In British Columbia, J. B. Foster photographed an adult male on 11 July 1975 at Fire Flats, Spatzizi (B.C.P.M. Photo #394), and a group of 10 adults and flying young was seen in this area by B. S. Ford on 12 August 1976 (BCNRS). An adult male collected near Atlin by I. McT. Cowan on 9 June 1958 is in the University of British Columbia Museum (CVM #8580). Evidence of breeding in the extreme northwest of British Columbia, although of long standing, has been indirect. C.H.D. Clarke on 17 July 1944 collected a female Smith's Longspur with a large brood patch at Kelsall Lake, km 120, Haines Road (Rand 1948). Since then, pairs and singing males have been observed irregularly in this area during the breeding season (Weeden 1960, S. G. Cannings *in* Grünberg 1979).

During June and July, 1979 and 1980, we found six Smith's Longspur nests near Chilkat Pass in northwestern British Columbia. Five nests were discovered

TABLE 1. Date found, stage of development, clutch size, and outcome of Smith's Longspur nests found in the Chilkat Pass area of northwestern British Columbia.

Nest-Year no.	Date found	Stage when found	Clutch size	Outcome
1–79	18 June	eggs	4	unknown
1–80	25 June	hatching	6	3 young fledged 9–14 July
2–80	25 June	eggs	5	hatched 26 June, 4 young 3 July; outcome unkown
3–80	28 June	eggs	5	hatched 29 June, 5 young fledged 8–11 July
4–80	2 July	nestlings	—	2 young fledged 2–5 July
5–80	1 July	eggs	5	unknown
6–80[1]	27 June	nestlings	—	4 very small young; outcome unknown

[1]Nest found by R. W. Campbell, British Columbia Provincial Museum.

in an area of approximately 60 ha close to Kelsall Lake, km 128, Haines Road. The sixth was located at Chilkat Pass, 25 km to the south. Nests were found accidentally by flushing incubating or brooding female longspurs while we were studying Willow Ptarmigan (*Lagopus lagopus*). Species identification was confirmed by R. W. Campbell of the British Columbia Provincial Museum, and photographs of adults at and near a nest were taken by E. Siam (BCPM Photo No 661). A seventh nest was found by R. W. Campbell near km 103, Haines Road, on 27 June 1980.

Nests were in subalpine tundra characterized by shrub cover of willow (*Salix* spp.), Dwarf Birch (*Betula glandulosa*) and Shrubby Cinquefoil (*Potentilla fruticosa*), and a ground cover of sedges, lichens, mosses and perennial forbs. The nests, built on flat exposed sites or in the sides of hummocks, were lined with dried sedges, grasses, and three contained several Willow Ptarmigan feathers.

We found nests on 18 June 1979 and between 25 June and 2 July 1980, and revisited four of them several times (Table 1). Clutch size varied from 4 to 6 with a mean of 5.0 eggs, which is larger than the mean clutch of 4.0 eggs (N = 26)[1] for Smith's Longspurs nesting near Churchill, Manitoba (Jehl 1968). Period of hatch (25–29 June) for the Chilkat nests in 1980 was about 5 days earlier than that described by Jehl.

Female longspurs at Churchill engaged in distraction displays when flushed from the nest during incubation (Jehl 1968). In the Chilkat Pass, females flew low and inconspicuously for a long distance, sometimes out of sight, when flushed from the nest. No defense of eggs or young was observed, except at one nest with two large nestlings, and here parental scolding was minimal.

Smith's Longspurs probably breed regularly in the Chilkat Pass. We observed other females and singing males for which nests were not located. The southern limit of the breeding range is poorly defined, but Smith's Longspurs probably nest throughout the southern regions of Alaska and the Yukon Territory, and in northwestern British Columbia, wherever there is suitable habitat.

We thank R. Wayne Campbell, Sydney G. Cannings, and Robert Montgomerie for critiques of the manuscript. Brina Kessel and C. Eric Tull provided helpful references. Grants from the Arctic Institute of North America, the Canadian Wildlife Service and the Frank M. Chapman Fund of the American Museum of Natural History to S. Hannon supported the ptarmigan project.

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Received 28 January 1981
Accepted 22 March 1981

Addenda: While this manuscript was in press D. Mossop communicated to the authors the following unpublished records: Chilkat Pass: 22 June 1971, nest with 4 eggs; 11 August 1972: adults feeding two fledged young; Aishihik Lake, 80 km W of Whitehorse; 2 August 1979, adult feeding a fledged young.

[1]We omitted one 2-egg clutch from the calculation since Jehl (1968) reported that probably it had been reduced in size by predation.

Myiasis by *Wohlfahrtia opaca* (Coq.): A Cause of Mortality of Newly Hatched Wild Ducklings

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Wobeser, Gary, Alvin Gajadhar, Gerry W. Beyersbergen and Lawson G. Sugden. 1981. Myiasis by *Wohlfahrtia opaca* (Coq.): a cause of mortality of newly hatched wild ducklings. Canadian Field-Naturalist 95(4): 471–473.

Three instances of fatal myiasis involving recently hatched Northern Shoveler (*Anas clypeata*) and Blue-Winged Teal (*Anas discors*) ducklings were found in central Saskatchewan during June 1980. Adult flies reared from the larvae were identified as the flesh fly *Wohlfahrtia opaca* (Coq.) (Diptera:Sarcophagidae); a species that has been reported as a cause of myiasis in mammals, but not in birds. The condition occurred in approximately 3% of the successful duck nests and 0.7% of ducklings known to be present on the area.

Key Words: ducklings, mortality, myiasis, *Wohlfahrtia opaca* (Coq.), *Anas clypeata, Anas discors.*

The causes of mortality of ducklings after hatching are seldom known in detail, although some brood attrition usually occurs between hatching and fledging. This lack of detailed information relates to difficulties in finding sick or dead ducklings before their removal by scavengers or predators. Myiasis, "the infestation of live human or vertebrate animals with dipterous larvae, which, at least for a certain period, feed on the host's dead or living tissue, liquid body substances, or ingested food" (Zumpt 1965), has been documented as a sporadic cause of mortality of young mammals (Capelle 1971), and reported in domestic waterfowl (Zumpt 1965). We are unaware of any descriptions of the condition in wild waterfowl. We report here three instances of myiasis, involving the death of seven ducklings, that occurred in central Saskatchewan in 1980.

Study Area and Methods

The ducklings were found during intensive searches for duck nests on a 388.5 ha Canadian Wildlife Service study area near St. Denis, Saskatchewan. The area is characterized by agricultural land interspersed with native vegetation and numerous small wetlands. Ducklings found dead were necropsied and histologic examination was done in some cases. Some fly larvae removed from the carcasses were identified to genus on the basis of external morphology, posterior spiracle pattern and cephaloskeletal structure (James and Gassner 1947, Faust and Russell 1964, Zumpt 1965). The remaining larvae were reared to adult by two methods. Some second- and third- instar larvae were placed on sterile peat moss in fly-proof containers and held in the dark at room temperature. The remaining second- and third- instar larvae were placed on the surface of 5% sheep blood agar in petri plates (standard microbiological media) in fly-proof containers and held in the dark at room temperature. Flies that emerged were identified with the key provided by James and Gassner (1947).

Results

On 11 June 1980, four Northern Shoveler (*Anas clypeata*) ducklings were found dead on the shore of a small wetland. The birds were in a group, as though the female had been brooding them at the location; at least one additional live duckling was present nearby. On the following day, 12 June, two Blue-winged Teal (*Anas discors*) ducklings were found dead on the shore of another wetland approximately 100 m from where the first birds were found. On 24 June a partially pipped Blue-winged Teal egg containing a dead embryo was found in a nest in the same general area. The remaining eggs from this nest had apparently hatched normally.

The gross findings were similar in all hatched ducklings, differing only in number and size of fly larvae present. There was wetting of the down with serous exudate on the ventral abdominal wall at the site of the umbilicus. A small circular opening, varying from 0.3–1.0 cm in diameter, was present in the skin at this site. Active fly larvae were evident within this opening and small 1–3 mm white larvae were present on the skin around the opening in a few of the birds. On dissection, there was an extensive subcutaneous "pocket" containing maggots on the ventral abdomi-

nal wall and extending into the space between the abdominal wall and legs. This cavity contained a small amount of serous yellow-brown fluid. In one Blue-winged Teal, larvae had entered the body cavity. The fly larvae within this pocket varied from 0.3–1.1 cm in length; 16, 23, 18 and 4 were recovered from the four Northern Shovelers and 11 and 23 were found in the two Blue-winged Teal.

The partially pipped egg was cracked in the normal hatching pattern for approximately one-half of its circumference; the tip of the duckling's bill protruded through the opening. A 0.6 cm perforation was present in the duckling's skin immediately caudo-ventral to the left wing. A total of 12 fly larvae ranging in length from 0.3 to 1.0 cm was present in the subcutaneous space underlying this perforation and within the body cavity. There was extensive intra-hepatic hemorrhage.

There was no gross or histologic evidence of other disease in these ducklings.

The larvae examined from all ducklings were identified as those of *Wohlfahrtia spp.* The second-instar larvae placed on peat moss failed to develop, but most of the third-instar larvae placed on this substrate pupated and developed to adult. Larvae placed on blood agar burrowed in, and apparently digested, the agar. The third-instar larvae pupated within 5 days, most of the second-instar larvae molted and then pupated within 1 to 2 weeks. Adult flies emerged from both media after 10 to 28 days. Approximately 90% of the adult flies that emerged were identified as the flesh fly *Wohlfahrtia opaca*. A few flies (Family Calliphoridae) also emerged, but they were not identified further.

Discussion

Wohlfahrtia opaca is widespread in western North America and has been reported from cases of cutaneous myiasis in several mammals including man (Gassner and James 1948, Haufe and Nelson 1957). No reports were found of infection with this species in birds. The fly is larviparous and the larvae are considered to be obligatory parasites of warm-blooded vertebrates, although development may continue in the carcass after death of the host (Gassner and James 1948). First-instar larvae can penetrate the unbroken skin of young animals (Gassner and James 1948); in the ducklings the larvae appeared to have gained entrance through the umbilicus. Ford (1933) found that females of a closely related species, *W. vigil* (Walker), were attracted to the eyes, perhaps due to moist exudate in this area; females of *W. opaca* may deposit their larvae near the umbilicus of recently-hatched ducklings, or through an opening in an egg, for the same reason. The cause of death in myiasis is unclear; however, young cottontail rabbits (*Sylvilagus floridanus*) died within 3 days after infection by *W. vigil* (Yuill and Eschle 1963) and ranch fox pups infected with as few as four larvae of *W. opaca* may die (James and Kraft 1964).

The recognition of three instances of myiasis on one small area within a 2 week period suggests that the condition may not be rare in ducklings. Altogether, 110 nests in which ducklings were known to have hatched were found on the area, and we estimate that approximately 1000 ducklings hatched from these nests. The three instances of myiasis found thus represented occurrence of the disease in almost 3% of known nests and in 0.7% of ducklings known to have hatched.

The lack of prior reports of myiasis in young waterfowl is understandable, because dead ducklings are difficult to find and the presence of maggots on a dead duckling would not seem unusual. A careful examination must be performed and the larvae identified to differentiate between the presence of species known to cause myiasis and the development of saprophytic fly larvae on a carcass dead from other causes. The few calliphorid flies reared from the ducklings probably represented the latter situation.

Myiasis caused by larvae of *Wohlfahrtia* spp. can produce severe losses among the young of domestic species, particularly mink and foxes, but the significance of these parasites for wild populations is unknown. Yuill and Eschle (1963) suggested that infection with *W. vigil* may affect populations of cottontails adversely, but this remains unproven. Boonstra (1977) believed that *W. vigil* had a relatively minor effect on a population of moles (*Microtus townsendii*), although up to 5.4% of the population was parasitized and only 5% of infected individuals were known to have lived for 2 weeks.

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Received 23 February 1981
Accepted 15 April 1981

Attempted Predation of Juvenile Starlings by Northwestern Crows

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James, Paul C. 1981. Attempted predation of juvenile Starlings by Northwestern Crows. Canadian Field-Naturalist 95(4): 473–474.

Northwestern Crows (*Corvus caurinus*) on Mitlenatch Island, British Columbia, were seen stooping on juvenile Starlings (*Sturnus vulgaris*) eight times. On two occasions, a Starling was captured but escaped. The crows have also been seen chasing juvenile Song Sparrows (*Melospiza melodia*).

Key words: Northwestern Crow *Corvus caurinus,* Starling *Sturnus vulgaris,* British Columbia, predation.

The Northwestern Crow (*Corvus caurinus*) is a well-known coastal scavenger and predator on bird eggs and nestlings (Butler 1974, 1979; Drent and Guiguet 1961; Vermeer 1963). However, its possible role as an active predator on full-fledged juveniles has not been recorded. This note reports attempted predation on juvenile Starlings (*Sturnus vulgaris*) by Northwestern Crows on Mitlenatch Island, British Columbia (49° 57′N, 125° 00′W).

A large flock of recently fledged Starlings usually feed and roost on Mitlenatch during the summer months. On 4 June 1979, I saw an adult Northwestern Crow attack a Starling in flight. The Starling had been feeding with about 20 others, which suddenly took flight. The crow flew down from above, where it had been sitting on the hillside. It grasped a Starling's back with both feet about 2 m above the ground, and held it for a second or two, while the Starling screamed loudly. The crow released it, and it dropped into some tall grass. The crow then turned sharply, and landed on a rock some 3 m away. It was soon joined by 10–12 other crows, which stood around calling. The original attacker and another bird walked about, apparently searching for the Starling, but gradually the crows dispersed. When all had left, H. Richardson and I searched and found the bird. It was not visibly damaged, but screamed loudly when picked up. When released, the bird flew strongly to a nearby tree, and then left the area.

The following day, I saw five stoops by crows on juvenile Starling flocks in flight in the same area. One Starling was caught as before, but escaped and flew to some nearby trees with the crow in pursuit. Six other crows landed at the top of the trees calling. A few minutes later, I heard loud screaming from a Starling, but could not determine what happened in the thick foliage. Further stoops on juvenile Starlings in flight were seen on 17 June and 8 July. On two occasions, I found the remains of juvenile Starlings, which may have been predated, on the island. N. Verbeek and J. N. M. Smith (pers. comm.) have also found remains of juvenile Starlings and Song Sparrows (*Melospiza melodia*) on Mandarte Island, B.C. (48° 37′N, 123° 18′W); although both suspect Northwestern Crow predation, they have never witnessed it. On 19 June and 25 July, I observed a colour-banded two-year-old male Northwestern Crow in pursuit of a juvenile Song Sparrow. On both occasions, the sparrow escaped into piles of rocks or logs on the beach.

Aerial predation or attempted predation has been reported for several species of corvids. The Common Crow (*Corvus brachyrhynchos*) has been seen pursuing smaller birds, including a Starling (Erskine 1980). The European Carrion Crow (*Corvus corone*) has

aerially attacked a number of species, again notably the Starling (Burgess and Smout 1976; Warren 1969), as has the Common Raven (*Corvus corax*) (Elkins 1964). Other corvid species recorded attacking birds in the air are the Magpie (*Pica pica*) (Pulman 1978), and Steller's Jay (*Cyanocitta stelleri*) (Carothers et al. 1972).

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Received 12 February 1981
Accepted 22 April 1981

A Probable Franklin's X Ring-billed Gull Pair Nesting in Alberta

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Weseloh, D. V. 1982. A probable Franklin's X Ring-billed Gull pair nesting in Alberta. Canadian Field-Naturalist 95(4): 474–476.

A Franklin's and a Ring-billed Gull were observed defending a common, active nest in a California/Ring-billed Gull colony near Edmonton, Alberta. The Franklin's Gull did all the observed incubation and was in attendance, with a nest, at the colony in two successive years. This is presumably the first known case of a Franklin's X Ring-billed Gull pair.

Key Words: Ring-billed Gull *Larus delawarensis,* Franklin's gull *Larus pipixcan,* nesting, Alberta.

On 1 June 1976 and 18 May 1977, I observed a single Franklin's Gull (*Larus pipixcan*) nesting on the ground in the midst of a large mixed California/Ring-billed Gull (*L. californicus*/*L. delawarensis*) colony (Figure 1) at Miquelon Lake, SE of Edmonton, Alberta. In both years the Franklin's Gull vigorously defended the nest against all adjacently nesting Ring-billed Gulls (there were no California Gulls nesting nearby).

On my visit in 1976 the nest contained two freshly hatched young and a pipping egg. In 1977 the nest contained three eggs. One of these was collected and is now preserved in the Provincial Museum of Alberta. The 1976 egg measured 60.2 mm × 45.0 mm, and the 1977 eggs averaged 60.8 mm × 45.2 mm. This is larger than the maximum measurements for eggs of Franklin's Gulls (56.5 mm × 38.5 mm, N = 48) but is very close to mean measurements for eggs of Ring-billed Gulls (5.9.3 mm × 42.3 mm, N = 40) (Bent 1921). In both years the eggs were similar in size and colour to eggs in adjacent nests of homogeneously paired Ring-billed Gulls. The two young, observed in 1976, also appeared identical to young of similar size from adjacent Ring-billed Gull nests (though possibly lighter in down coloration and with smaller bills).

The 1977 nest was located in the same area of the colony as was the 1976 nest. In 1977, an adult Ring-billed Gull was also attending the nest. This was presumably the Franklin's Gull's mate as it was the only gull tolerated and not attacked by the former near the nest. The Franklin's Gull did all the incubation during my observation (15-20 minutes) although both it and the Ring-bill frequently defended the nest and attacked other nearby gulls. In 1976, I was unable to locate a second gull at the nest, but the 1977 sighting and the large dimensions of the eggs in both years

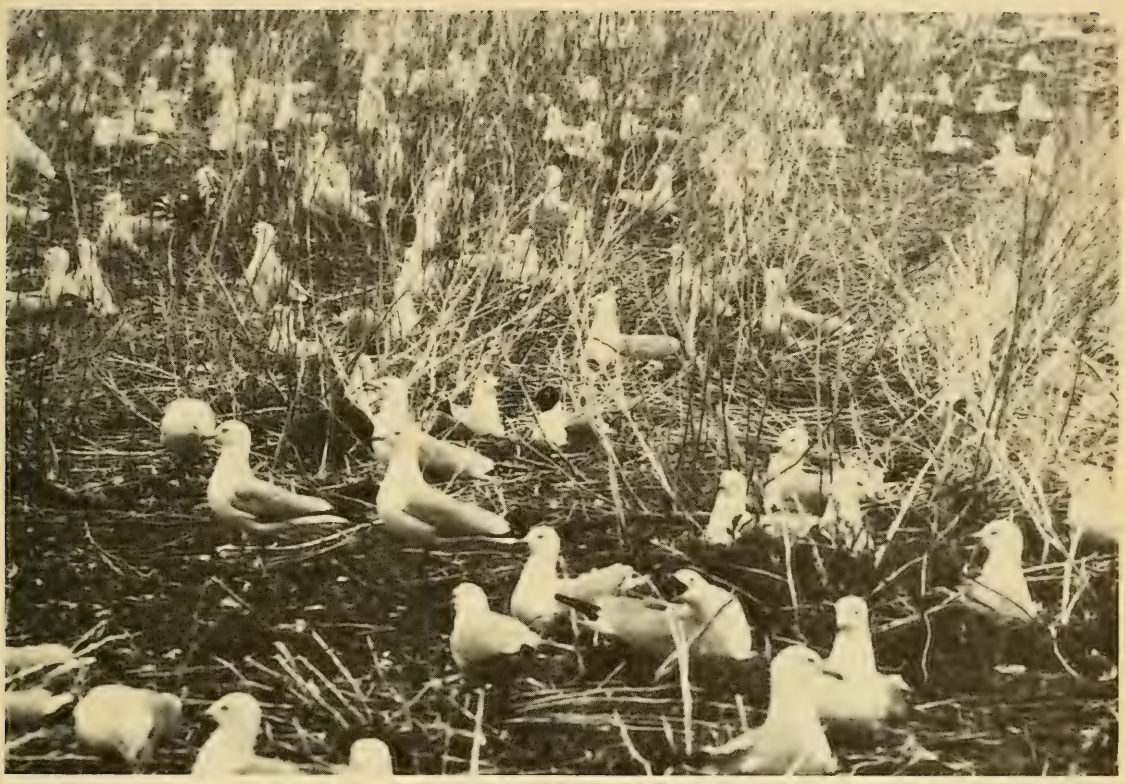

FIGURE 1. A Franklin's Gull at its nest in a colony of California and Ring-billed gulls, Miquelon Lake, Edmonton, Alberta.

strongly suggest that both nests involved both Ring-billed and Franklin's Gulls.

The origin of the nest contents and of the interspecific pair is open to speculation. The eggs were 17% wider (only 7% longer) than the largest Franklin's Gull egg and, therefore, probably laid by a Ring-billed Gull. This could have been the result of a male Franklin's Gull paired and mated to a female Ring-billed Gull forming a true hybrid pair. Alternately, it may have resulted from the loss of one member of a mated Ring-billed Gull pair and the survivor's subsequent behavioral pairing with the Franklin's Gull. The original Ring-bill pair may have been either heterosexual or homosexual as Ryder and Somppi (1979) have shown that the latter are able to produce fertile eggs, presumably as a result of prior insemination.

Depending on how the interspecific pair arose, the Ring-billed Gull may or may not have been the same individual in each year. The Franklin's Gull, however, almost certainly was the same individual in each year. The near identical location of its nest in both years suggests a strongly developed site tenacity in the Franklin's Gull. I would more readily expect such site tenacity from a true interspecific pair rather than from birds only behaviorally paired.

The occurrence of a Franklin's X Ring-billed Gull pair at the colony of either species is an unusual occurrence; I am aware of no previous records, and Gray (1958) records none. However, if this was a true hybrid pair, there is a relatively obvious explanation. Although the nesting habitat of the two species is quite different, it is fairly easy for these two species to nest in close proximity to one another. Ring-billed Gulls usually nest on islands in lakes, whereas Franklin's Gulls nest in emergent vegetation in lakes. In Alberta there are or have been colonies of both species, simultaneously, on at least Beaverhill Lake (colonies 6.5 km apart) and Frank Lake (0.6 km apart) (personal observation). To the best of my knowledge, Franklin's Gulls do not and have not nested on Miquelon Lake. On lakes where both species nest, it is possible that a young Franklin's Gull could wander or be washed onto a colony of Ring-billed Gulls and become imprinted to them. This could eventually lead to a Franklin's X Ring-billed Gull pair as witnessed here.

I wish to thank Terry Thormin, Al Wisely and Ludo Bogaert who accompanied me to the island in one or other of the years. The observations were made while I was employed at the Provincial Museum of Alberta. I also thank Pierre Mineau and two anonymous reviewers who commented on an earlier version of the manuscript.

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Received 2 February 1981
Accepted 25 March 1981

Nesting of Brewer's Blackbirds on Man-Made Structures and Natural Sites in British Columbia

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Butler, Robert W. 1981 Nesting of Brewer's Blackbirds on man-made structures and natural sites in British Columbia. Canadian Field-Naturalist 95(4): 476–477.

In British Columbia, Brewer's Blackbirds (*Euphagus cyanocephalus*) that nested on man-made structures began egg laying at approximately the same date and had similar clutch sizes to nests in natural sites. Nests in natural sites were built closer to the ground, had a longer egg laying season, and fledged more young per egg laid, on average, than nests on man-made structures. Man-made sites were apparently used chiefly early in the season when some natural sites lacked concealment.

Key Words: Brewer's Blackbird, *Euphagus cyanocephalus,* British Columbia, breeding, man-made sites.

The Brewer's Blackbird (*Euphagus cyanocephalus*) commonly nests on the ground, in shrubs, and in trees (eg. Bent 1958, Stepney 1975, Walkinshaw and Zimmerman 1961). I can find only one reference to this species nesting on man-made structures. Edwards & Ritcey (1967) mentioned that Brewer's Blackbirds nested on buildings in Wells Gray Park, British Columbia, but they did not document the nesting success. The purpose of this paper is to document and compare nesting data of the Brewer's Blackbird in nests built on man-made structures and in natural situations in British Columbia.

Data were collected in the field and supplemented from the British Columbia Nest Record Scheme with a sample of natural site nests with completed clutches and all man-made site nesting attempts. Nests built on man-made structures in British Columbia were found on support beams (11), wooden ledges (7), fence posts (5), telephone poles (3), haystacks (2), and a road-grader (1). Nests built on man-made structures ($N = 25$) were significantly higher off the ground ($\bar{x} = 3.3$m) than nests built in natural situations, including nests on the ground ($N = 54$, $\bar{x} = 1.1$m; $p < 0.01$).

The earliest records for first eggs were 17 April and 23 April, in nests in natural and man-made sites, respectively. However, egg laying ceased by 28 May in nests found on man-made structures but continued until 28 June in nests in natural sites. Most late clutches in natural sites were presumably second attempts. There was no significant difference between egg initiation dates in nests in natural and man-made sites within the province. However, when the data were pooled without regard for nest site, those nests ($\bar{x}$ = 3 May) west of the Coast Range held first eggs significantly earlier than nests ($\bar{x}$ = 16 May; $p < 0.01$) east of the Coast Range. Mean clutch sizes were similar but the number of young that fledged per egg laid was significantly different between nest sites (Table 1).

Howard (1974) suggested that American Robins (*Turdus migratorius*) nested in coniferous vegetation early in the season because of a shortage of concealed sites in deciduous vegetation. Horvath (1964) also suggested that seasonal changes in micro-climate around the nest caused the Rufous Hummingbird (*Selasphorus rufus*) to shift its nest site. In this study, some Brewer's Blackbirds nested on man-made structures in the early part of the nesting season whereas

TABLE 1. Reproductive data of Brewer's Blackbirds nesting on man-made structures and natural sites in British Columbia (sample sizes).

	Natural site	Man-made site
Clutch initiation dates, range	17 April-28 June	23 April-28 May
median	13 May (41)	18 May (22)
Clutch size, mean ± s.d.	5.0 ± 0.8 (40)	5.4 ± 0.9 (21)
Number of young fledged per egg laid.*	0.48 (144)	0.36 (72)

*significant difference exists, $p < 0.01$.

natural sites were used throughout the season. This suggests that nests on man-made sites offered better concealment than many natural sites early in the season. The data from the Nest Record Scheme seldom contained information on whether the same individuals shifted their nest site. A population could consist of early and late nesters that preferred different sites. However, I am reasonably certain from my observations of nests at the Creston Valley Wildlife Interpretation Centre in 1980 that the same Brewer's Blackbirds shifted their nest sites as the season progressed because all five second nests (in natural sites) were within a few meters of first nests (mostly on structures). In addition, one female, recognizable by her amber-coloured irises, shifted her nest site from under a walkway to the ground a few meters below.

J.P. Goossen assisted in the field and D. R. Flook and J. Grant made useful comments on the manuscript. G. E. J. Smith provided statistical advice and R. W. Campbell allowed access to the British Columbia Nest Record Scheme. I thank all of you.

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Received 22 September 1980
Accepted 14 October 1981

News and Comment

Amendment to By-laws of The Ottawa Field-Naturalists' Club

1. By-law 3. Strike out the sentence "It shall recommend to the Council candidates for Honorary Membership".
2. Addition of two new by-laws:
   (19) Duties of the Awards Committee:
   The Awards Committee shall be responsible for nominating deserving members of the Club for Honorary Memberships, Special Club Awards and for awards offered by other clubs and organizations.

   (20) Duties of the Executive Committee:
   The Executive Committee shall propose policy direction, deal with areas which are sensitive or difficult, act as a continuum of thought, deal with emergency matters and call upon other persons for advice when necessary.

E.F. Pope
Recording Secretary

Changes in By-laws, Ottawa Field-Naturalists' Club

A motion to change By-law 15 of The Ottawa Field-Naturalists' Club was passed by 13 votes to 2 by the Council at the meeting of 23 November 1981. This by-law now reads as follows:

15. Membership Dues
    The schedule of dues shall be as follows:

Individual	$13.00
Family	15.00
Sustaining	30.00

    Life membership shall be granted upon payment of a single sum of $300.00

A motion to change By-law 16 of The Ottawa Field-Naturalists' Club was passed unanimously by the Council at the meeting of 14 December 1981. This by-law now reads as follows:

16. Subscription Fees
    The schedule of subscription fees shall be as follows:

The Canadian Field-Naturalist	
Individual	$13.00
Libraries and Institutions	25.00
Trail & Landscape	
Libraries and Institutions	13.00

E.F. Pope
Recording Secretary

New Honorary Members of the Ottawa Field-Naturalists' Club

In 1980 four outstanding members of the OFNC were awarded with Honorary Memberships in recognition of their immense contributions to the Club and/or to Canadian natural sciences. They join the select group of important Canadian naturalists who have previously been so honoured.

Dr. Clarence (Clarie) Frankton

Clarie served on the OFNC Council for 15 years between 1947 and 1961 and was instrumental in reorganizing our Reserve Funds to provide a greatly increased rate of return. He has also served in a wide range of projects including the conservation areas program, Christmas Bird Count and Club excursions. He served as OFNC Auditor for 10 years and was Treasurer of the Club between 1947 and 1949. His detailed knowledge of the natural values in the west end of the Ottawa area was particularly vital in the efforts to establish Conservation Areas (such as the Carp Hills, South March Highlands and Bridlewood) in the Official Regional Plan of the Regional Municipality of Ottawa-Carleton.

Perhaps his greatest contribution to the OFNC has been the easy grace with which he shared his expert botanical knowledge and has encouraged the development of amateur naturalists within the Club. A number of OFNC members who are now working professionally in the natural sciences owe a great deal of credit for their development to the inspiration and

guidance of Clarie Frankton. His enthusiasm for and love of the natural world transcends his considerable scientific knowledge and is truly an inspiration for those fortunate enough to share a day in the field with him.

Dr. Frankton retired in 1970 as Head of Taxonomy for the Plant Research Institute (Agriculture Canada). His important studies of weedy plants have had considerable economic and scientific significance. Although he has published many scientific papers in those areas for which he established an international reputation, he is perhaps best known to Canadian naturalists for his book *The Weeds of Canada*. Although first published in 1955, it is still much in demand, particularly after it's revision in 1970 (with G.A. Mulligan).

Dr. Frankton was presented the Lawson Award by the Canadian Botanical Association shortly after his retirement. This award is presented only when the CBA deems that a particularly significant contribution merits such high honour.

Clarie Frankton exhibits a rare combination of long and outstanding service to the OFNC and to natural science. It is only fitting that the Club acknowledge this extraordinary achievement by electing him an Honorary Member.

Mary E. Stuart

Since becoming a member of the OFNC in 1945 Mary Stuart has been a dedicated and valuable Club enthusiast who has contributed to a great many services and programs. She served on Council from 1948 until 1972 and on a number of committees, including Membership, Special Lectures, Publicity, Christmas Census and Excursions & Lectures. She was particularly active in the organization, meetings and outings of the very successful Bird, Fern, Orchid and Trail study groups in the late 1950's and early 1960's. She also was highly involved in the early days of the *Newsletter*. To fill in her idle (!) hours she organized field trips, Annual Dinners, evening nature walks, and so on.

If the Club ever had a social hostess, Mary was it. Friendly and gracious, she welcomed new members at Annual Meetings, club outings, picnics at the Beatty Point Lodge, and wherever the OFNC gathered. She made people feel right at home and always had a supply of Club literature to encourage new members. In later years she has been very generous in offering her farm near Packenham for OFNC excursions. The Macoun Club, in which she maintains an interest, has made a tradition of enjoying regular camping trips to her property to study natural history.

For her unassuming manner, enthusiastic support, and dedicated service to the OFNC, we are delighted to number Mary Stuart amongst our distinguished Honorary Members.

D. B. O. Savile

By profession a mycologist with more than one hundred research publications to his credit, Dr. Savile has received world-wide recognition and acclaim for his work on the plant rusts (*Uredinales*). His many honours include membership in the Royal Society and a recently confered honorary doctorate from McGill University.

Doug has been an active member of the OFNC since 1944. He served on Council for many years and was particularly involved in financial affairs. He has produced some of the most original and significant observations on natural history of any Club member. He has long advocated the necessity for a broad knowledge in many fields of natural history in order to fully understand and interpret the natural world. His own talent for astute observation and his genius for grasping the significance of what he sees can be seen by mentioning only a few of the score of topics on which he has published : bird navigation and flight, evolution of the avian wing, gliding and flight mechanics in vertebrates, splashcup and springboard methods of seed dispersal, arctic adaptations in plants, meteorology, plant geography — and so on. Doug Savile's numerous and scholarly contributions to our knowledge of natural history rank him with the top naturalists of the century. The OFNC is proud to consider him one of our Honorary Members.

R. Yorke Edwards

Yorke has been a member of the OFNC since 1942 although he was active in Toronto naturalists' circles somewhat before that. In this time he has become one of Canada's best known naturalists. He has written over 200 articles on various natural history subjects (although birds have always been a particular favorite of his), as well as two books on natural history and interpretation.

He is a pioneer of Canadian interpretation. His persistence and persuasive arguments saw the first British Columbia park interpretation program initiated in 1949. As interpretation specialist for the Canadian Wildlife Service, he developed the Wildlife Service's system of interpretive centers. Untold numbers of Canadians have benefited either directly or indirectly from Yorke's interpretive efforts, and have developed a new awareness of some of Canada's important natural values.

Yorke is presently Director of the British Columbia Provincial Museum in Victoria. He continues to serve

various conservation organizations and to write thought-provoking articles on interpretation and conservation. For over 30 years he has made significant personal contributions in each of the areas of concern outlined in the objectives of the OFNC. It is indeed appropriate that we award Yorke Edwards with an Honorary Membership.

D. F. BRUNTON

The assistance of notes from S. Thomson, D. Gray and V. Humphreys is gratefully acknowledged.

Support for Field Research

The Center for Field Research offers funding and volunteer assistance to postdoctoral scholars needing support for field research. Working cooperatively with EARTHWATCH, a national volunteer organization, The Center sponsors seventy field research projects each year in the sciences and humanities, and in 1981 will send $700,000 and 1200 volunteers into the field. Proposals for 1982-3 research are now being reviewed.

Eligibility: Qualified projects are reviewed for scholarly merit and their ability to constructively utilize teams of volunteers in the field. EARTHWATCH volunteers, a work force and funding source in one, pay a share of project costs and assist in the field work. For example, a coastal geologist studying barrier island migration needs three two-week teams, of minimum 4 — maximum 10 volunteers each, to assist in sampling and beach profile surveys. If each volunteer contributes $500 toward project costs, a total grant of $6,000 — $15,000 is provided.

The Center invites proposals from postdoctoral scholars of all nationalities and is committed to sponsoring the research efforts of qualified women and minority investigators.

Areas of Interest: Projects in any recognized academic discipline are welcome, i.e., anthropology, archaeology, art history, biology, folklore, geology, marine science, musicology, zoology. Interdisciplinary proposals are also invited.

How to apply: Submit a two-page Preliminary Proposal outlining your research objectives, project dates, planned use of volunteers, and need for funds. Following favorable review, a Formal Proposal will be invited, which must precede field work by nine months.

For application guidelines, and a listing of projects currently receiving support, write:

Nancy Bell Scott
Center for Field Research
Box 127-U, 10 Juniper Road
Belmont, MA 02178

Grants Available for Bird Projects

The James L. Baillie Memorial Fund for Bird Research and Preservation invites applications for grants to support projects on Ontario birds in 1982.

The fund's aim is to encourage field studies by amateur naturalists and to support projects which increase or disseminate knowledge of birds in their natural environments or contribute to their preservation. Priority will be given to projects which draw on the resources of volunteer naturalists in conducting field research of fieldwork and to applicants who do not have access to other sources of support.

Examples of eligible projects might include (but are not limited to) individual or group research by amateur naturalists, distributional or other surveys using information contributed by volunteers (e.g. Christmas Bird Counts) and publication of local guides or checklists.

Grants will not normally exceed $750. Applications are due by December 31, 1981, and should be submitted on forms obtainable from the Secretary, James L. Baillie Memorial Fund, c/o Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0.

The James L. Baillie Memorial Fund approved 10 applications totalling about $4,500 in 1981. The Fund is financed in part from the proceeds of the Jim Baillie Memorial Bird Count (Baillie Birdathon). Donations to the fund are tax deductible and may be sent to the address given above.

Common Tern Colour-Marking by the Canadian Wildlife Service: Request for Information

During 1981, Dr. Hans Blokpoel of the Canadian Wildlife Service, colour-marked Common Terns at two large colonies in the Great Lakes area, with the objective of determining the year-round distribution of the birds, especially their migration routes and wintering areas in Latin America. Adult Common Terns were trapped on their nests at the Eastern Headland of the Toronto Outer Harbour (Lake Ontario) and at Tower Island (Niagara River). Orange plastic tags were attached to both wings of the trapped adult birds. In addition, young Common Terns were marked with pink plastic wing tags at those colonies. One standard metal leg band and one coloured plastic leg band (yellow with a black horizontal stripe) were put on each of the tagged birds.

If you see a Common Tern with a pink or orange wing tag please record the following details: place, date and colour of the tag. If possible, also record the combination of numbers and/or letters on the tag (the two tags on any bird have the same color and the same combination of letters and numbers) and note which legs the plastic and metal leg bands are on. Thank you very much for your assistance. All reports will be acknowledged and should be sent to:

Bird Banding Office
Canadian Wildlife Service
Ottawa, Ontario, Canada
K1A 0E7

Wood Buffalo National Park Management Planning Program

Parks Canada is presently engaged in a Management Planning Program, which, when completed, will determine the long range direction for the future use and management of Wood Buffalo National Park.

The park, which straddles the Alberta/N. W. T. border, is 44,807 sq. km in size and protects a natural area of Canadian significance representative of the Northern and Southern Boreal Plains of Canada.

Significant resource features within the park include portions of the Birch and Caribou Mountains, one of the largest fresh water deltas in the world, extensive karst fields, vast salt plains, the largest free roaming herd of bison in the world, important archeological sites and nesting sites of the endangered Whooping Crane and Peregrine Falcon.

The park is largely undeveloped but does contain a limited number of facilities including a 36 site campground and a group camp located at Pine Lake, 66 km S. W. of Fort Smith, N.W.T. Associated with this development is a day use area, an interpretive theatre and display building, a boat launch and seventeen privately owned cottages situated on lots leased from Parks Canada.

Access to visitor facilities in the park is provided primarily by a gravel loop road that extends S. W. from Fort Smith, N. W. T.

Management Planning issues centre largely around resource management concerns such as fire management policy, management of the Bison herds, hunting, trapping and subsistance fishing privileges, commercial logging practises, possible changes to the park boundaries, preservation of special areas and features in the park. At question also is the future of native settlements within the park. What level of recreational use and the location of any additional recreational facilities must also be determined. At issue also is the appropriate level of access into the park via road, air, and water.

Several regional issues such as the Slave River hydroelectric proposal and its impact on the park, native land claims, regional development and tourism must also be addressed in the planning process.

Public meetings are now underway to permit the public to exchange information with the planning team and identify and discuss planning issues. In the fall of 1981, the planning team will meet with the public again to present a number of alternate plans and receive comments.

Following this alternative plan stage a draft management plan will be prepared and will be made available for public review and comment. After this public review, the final plan will then be prepared and presented to the Minister responsible for Parks Canada for final approval.

The public is invited to participate in all stages of the planning process and the planning team, based in Fort Smith, welcomes input. If you would like to receive copies of newsletters dealing with the planning program, make your views known, require information, or wish to have your name placed on the mailing list, please contact the Public Participation Coordinator, Wood Buffalo National Park Management Planning Program, P.O. Box 750, Fort Smith, N. W. T. X0E 0P0, phone: (403) 872-2649.

Environmental Monitoring: a Symposium

The Alberta Society of Professional Biologists is pleased to announce a symposium entitled "Environmental Monitoring", to be held on 20 and 21 April 1982, at the Westin Hotel (formerly Edmonton Plaza) in Edmonton, Alberta.

The symposium will examine the question of why environmental monitoring is required, examine the design basis of environmental monitoring, the practical aspects of conducting environmental monitoring, the results of existing environmental monitoring programs, and the value of biomonitoring programs. Eminent speakers from universities, government and private industry will be featured.

- *Date:* 20 and 21 April 1982
- *Location:* Westin Hotel (formerly Edmonton Plaza)
- *Registration and Further Information:*
  Don Thompson
  Secretary
  Alberta Society of Professional Biologists
  P.O. Box 566
  Edmonton, Alberta
  T5J 2K8

  Telephone: (403) 429-9110

XVth Pacific Science Congress, 1983

The XVth Pacific Science Congress will be held in Dunedin, New Zealand, 1-11 February 1983. Its theme is to be "Conservation, development and utilization of the resources of the Pacific".

A session is planned on the diversity, distribution, abundance and management of vertebrate populations in the Pacific region. Joint sessions will be arranged with related disciplines. Speakers are now invited to offer papers (with title and short summary) on such topics as: —

Biogeography
Species diversity
Habitat requirements
Migration and movements
Population ecology
Ecosystem studies
Man-induced changes
Endangered species
Conservation and management

For further information, please write to Dr C W Burns, Section Convener, (Ecology and Environmental Protection), c/o Department of Zoology, University of Otago, P O Box 56, Dunedin, New Zealand.

Errata

Please note the following corrections to The Canadian Field-Naturalist 95 (3) :

p. 241 KEDDY: Relict Lakeshore Vegetation : Table 1: the annotations * and † are reversed at the bottom of the table; correct to

* Species with costal plain affinities
† Rare in Ontario (Argus and White 1979)

p. 356 SOUTHIERE and STEVENTON: Seasonal Pelege Change of Martin: line 2 of the right hand column of text should preceed line 1 in this column so that the paragraph beginning at the bottom of the left hand column reads:

"Two specimens exemplifying the extremes of winter color are filed in the Wildlife Resources Museum University of Maine ..." etc.

p. 363 PRUITT: Application of Värriö Snow Index : Figure 1: substitute in the legend "n, number of api stations" for "n, number of Caribou".

p. 376 LOVE: [Review of] North American Birds of Prey: "By William Marshall" should be changed to read "By William Mansell"

The editor is grateful to Paul A. Keddy, J. Douglas Steventon, W. O. Pruitt, Jr., and William Mansell for bringing these to his attention.

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Book Reviews

ZOOLOGY

A Manual of Mammalogy; with keys to families of the world

By Anthony F. DeBlase and Robert E. Martin. 1981. 2nd edition. Wm. C. Brown, Dubuque, Iowa. xii + 436 pp., illus. U S $9.95.

This is the most complete laboratory manual available in mammalogy. This edition is much improved over the first. Six new chapters appear and others are entirely rewritten. Illustrations are now abundant. Discussions on mammalian abundance, appendicular skeletons, antlers, claws, extoparasites, hoofs, horns, locomotion, nails, population dynamics, reproduction, sign, skin, skulls, systematics and teeth are dealt with in their own chapters. About 100 pages are devoted to explaining methodologies concerning age determination, data recording, diet analysis, identification, literature searches, marking, specimen preparation and preservation, statistical analyses, and trapping. Each mammalian order is described in detail. Distinguishing characteristics, distribution, fossil history, identification keys, line drawings of representative species, skull diagrams, supplementary reading lists and taxonomic discussions are given for most all mammalian families of the world. There now is especially good treatment of bats and rodents. A good glossary and index make the text a useful quick reference.

This manual would work well as a guide in a mammalogy course, but it could easily be used for wildlife management, vertebrate zoology, applied ecology, or mammalian taxonomy courses. Serious naturalists interested in the scientific study of mammals would find a copy useful.

RICHARD M. ZAMMUTO

Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7

The Great Gray Owl: phantom of the northern forest

By Robert W. Nero. 1980. Smithsonian Institution Press, Washington, 167 pp., illus. $21.

At long last, the account of Bob Nero's extensive studies of the Great Gray Owl in and about southern Manitoba has been published in one volume — and it's a gem. It is well-bound, beautifully illustrated and nicely laid-out. The copy is printed in two well-spaced columns in an easy-to-read typeface. Thirteen chapters, each dealing with some major topic of Great Gray Owl biology, are accompanied by a thorough bibliography and a well-detailed index. The copy is remarkably free of errors.

Each chapter is introduced by a vignette of the topic at hand, written in beautiful prose. One can easily see that Nero comes from Aldo Leopold country! The subject comes alive — and this is a great strength of the study throughout. Nero quotes freely and comfortably from his field notes (and those of his associates) in the present tense. The reader is so effectively carried along by the text in this way that he can "see " the scenes being described. Within each chapter, the tremendous personal contribution, by Nero, to our knowledge of the Great Gray Owl is evident — as is his love for these creatures and their environment. No clinically sterile data base, these birds!

The careful placement of the spectacular photographs of Robert R. Taylor compliment the text enormously. If there was any doubt that Taylor is a giant in his field, this book destroys it. The reader is treated to a full array of stunning black and white and colour photographs of the Great Gray Owl and its world. These pictures illustrate numerous subtle and spectacular features alike and are artistically and technically superb. The latter quality is waived only once (on page 132) in order to illustrate a precise action. A particularly innovative photograph (page 76) superimposes a skull on a feathered head to (very effectively) illustrate the relatively small body size of this owl. Captions are excellent, adding understanding (not just description) of each photograph for the reader. They also offer interesting tid-bits (e.g. the identification of immature birds by tail feather characteristics).

Data are presented in a narrative form; the reader is directed to upcoming scientific papers for a detailed rationalization and analysis of Nero's findings. This narrative style has made the book very readable but does not reduce its credibility. Nero's writing is lucid, credible and enjoyable. The subject coverage is very complete, dealing with the Great Gray Owl's behaviour, physiology, nesting habits, population trends, research techniques, etc. These are discussed in a lar-

gely smooth and natural manner although the flow becomes a bit ragged towards the end of the book. Preening is covered in Chapters 6 and 9 as is interspecific conflict in Chapters 7 and 8 — both of which could have been dealt with in single chapters. Chapters 3 (An Owl in the City) and 10 (A Nesting of Owls) though beautifully written are really expansions on topics discussed satisfactorily in other chapters and are therefore redundant.

For Nero this book and the studies that went into it were obviously labours of love, a feeling he wishes to share. The better part of Chapter 11 is a manual for would-be Great Gray Owl nest-finders — complete with words of caution and warning. This is a particularly delightful "welcome" for the reader from the author.

Nero estimates that there may be 50,000 of these magnificent owls in North America and expresses quiet concern that trapping, forest management and agricultural practices may be having a detrimental effect on that population.

This book is clearly the definitive work on the Great Gray Owl in North America. Nero's reasoned, poetic and at times passionate writing does justice to the majesty of his subject. For those of us who have waited almost ten years for this book to be published, it was worth the wait. I'll summarize my opinion of the book by using Nero's own words . . . "gawd how I loved it all"!

DANIEL F. BRUNTON

2683 Violet Street, Ottawa, Ontario K2B 6X1

The Warblers of America

Edited by Ludlow Griscom and Alexander Sprunt, Jr. (Revised and updated by Edgar M. Reilly, Jr.). 1979. Doubleday, Garden City, New York. 302 pp. US $19.95.

When I first heard that the 1957 edition of *The Warblers of America* was to be revised and updated, I was very excited because the warbler family is my favorite group of birds. After comparing the 1979 update with the first edition, I must say that I had hoped for more. Although there are undoubtedly some improvements, the greatest benefit is once again making available to the birding public a long out-of-print popular account of warblers at a still very reasonable price.

Changes include lumping of the Myrtle and Audubon's, and the Parula, Olive-backed, and Socorro; some new range maps although most remain unchanged; new chapters for Central America and the West Indies; and a new order of presentation of species, which now follows that found in Peters, *Birds of the World*. While there is a new species account for the Yellow-rumped (lumping of Myrtle and Audubon's), Reilly has retained the "old" species accounts for the Parula and Olive-backed.

The nice 35 full-color plates by John Henry Dick are now grouped at nine locations rather than being distributed singly throughout the book as found in the 1957 edition. Comparing the quality of the plates in the two editions, I found those in the older edition to be sharper, with a richer color. Several of the plates in the revised edition have a greenish tint. Loss of some sharpness may be a result of the increased page size, which reduced the total number of pages from 356 in the first edition to 302 in the 1979 edition.

The seven introductory chapters remain unchanged with a few very minor exceptions. The 358 species breeding in the United States, Canada, and Baja are then presented. Each species account is accompanied by a range map and information typically found in species write-ups. Often included in the 1½-3½ pages devoted to each species is a black-and-white line drawing. Species accounts are followed by 11 chapters on warblers of other western hemisphere regions.

In the appendix on the classification of the warbler family Parulidae, a subspecies regional name has been added in the new edition. An irritating change in the 1979 edition is the deletion of species page numbers in the Table of Contents. One can no longer check the Contents to find the page number for a particular species. On the other hand, an improvement in the new edition is the expansion of the index from just a species index to a full subject index.

While this volume still provides invaluable information on this most interesting group of birds, I was hoping for more incorporation of information accumulated over the past 20 years into the revised edition. However, a price of $20 for a 300-page bird book with 35 color plates is a steal, and it will continue to provide interesting reading and prove to be a useful reference whenever it is consulted.

NOEL J. CUTRIGHT

Wisconsin Electric Power Co., 231 W. Michigan, Milwaukee, Wisconsin 53201

Butterflies and Moths of Newfoundland and Labrador: the Macrolepidoptera

By Ray F. Morris. 1980. Research Branch Agriculture Canada Publication 1691. Supply and Services Canada, Hull. 407 pp., illus $15.00 in Canada; $18.00 elsewhere.

The completion of this excellent book has been a life long goal for Ray Morris. It brings together a great deal of his original research to document the biology of the many introduced and native macrolepidoptera from this most easterly part of Canada. Mr. Morris emphasizes larval feeding and points out many information gaps in life cycles thereby accentuating future research objectives. The text has a logical and concise format in clear bold type. This very readable, hardcover book with its many photos, illustrations, distribution maps and 34 colour plates of adult stages is an outstanding bargain at $15.00. I'm sure this will be a key text for students and researchers well into the 21st century.

ROBIN T. DAY

Biology Department, University of Winnipeg, Winnipeg, Manitoba R3B 2E9

Les salmonidés des eaux de la Plaine de Montréal: 1. Historique, 1534-1977 et 2. Biometrie, biogéographie, 1970-1975, et registre des pêches 1941-1976.

1. Par Vianney Legendre, Jean-René Mongeau, Jean Leclerc et Jocelyne Brisebois. 1980. Ministère de Loisir, de la Chasse et de la Pêche, Service de l'aménagement et de l'exploitation de la faune, Québec. Rapport Technique N° 06-27. 280 pp., illus. et 2. par Jean-René Mongeau, Vianney Legendre, Jean Leclerc et Jocelyne Brisebois. 1980, 2nd edition. Ibid. Rapport Technique N° 06-28. 139 pp., illus.

This work is a delight to read because Vianney Legendre and his team are well-versed in fishery biology, possess a rare degree of expertise in writing, and display a deep knowledge of history and literature that both document and embellish their writings.

An in depth study and interpretation of the literature combined with a knowledge of the upper thermal and lower oxygen tolerance of the Atlantic salmon, *Salmo salar*, demonstrate that historically anadromous populations did not ascend the St. Lawrence River much further upstream than Québec City and therefore did not reach Montréal* or the Richelieu River. Populations in Lake Champlain and Lake Ontario must have been land-locked. Documentation, from one of the finest natural history libraries in Canada (built up by Vianney Legendre) is provided from the works of Samuel Champlain, the Jésuite Relations, Pierre-Espirit Radisson to those of modern studies on Quaternary geology. If we do not find reference or a footnote to Philippe Aubert de Gaspés chapter "Le Lac Trois-Saumons" from his 1866 *Mémoires*, we can be confident it was not omitted because the authors were unaware of it, but rather through judicious selection.

The distribution of salmonids in the St. Lawrence is also documented from the excellent and thorough fish collections of the Ministry. Unlike those of most provinces these collections have been made according to a systematic plan, and the results published.

From this evidence the authors are able to point out the ecological lacunae for salmonids in rivers of the Plaine de Montréal, voids which introduced rainbow and brown trout have profited by, in spite of pollution in the region. Current ministerial reorganization for protection of the aquatic environment will doubtless benefit the catch of salmonids and other fishes.

The second volume deals more closely with the management and evaluation of success of fisheries programs. A valuable long-term evaluation indicates that plantings of some species have shown extraordinary returns to the anglers while those of other species should be discontinued.

The third chapter of the same volume explores the role of smelt as a sport and as a forage fish. The pygmy smelt is not mentioned. The studies of C. E. Delisle and D. Copeman have convinced the reviewer that Québec has two kinds of smelt, one large and widespread and one small, the pygmy smelt and known in the world only from Heney Lake, Québec and Green Lake, Maine. The pygmy smelt, which feeds almost entirely on plankton, would make an ideal forage species. It would be worthwhile in the reviewer's opinion to try and introduce it in lakes which lack ciscos or whitefishes as planktivores. The introduction should be made using eggs, not adults which might be infected with *Glugea hertwigi*. The stock of pygmy smelt and Lake Heney should be protected from harmful environment changes.

In the smelt chapter as elsewhere, Legendre and his team show a mastery of language and imagery that the man on the street, the scientist, and even a linguisti-

*May occur as a very rare phenomenon as one did see recently (pers. com. V. Legendre), not as a regular migration.

cally untalented reviewer can enjoy and be enriched by. The flowing and beautiful phrases are particularly striking in what could have been a dry explanation of how the smelt eats plankton a thousand times smaller than ifself and, in turn is eaten by a trout a thousand times larger. The smelt thus acts as a converter (transformateur) of energy.

The final section of volume two is devoted to conclusions and carefully considered recommendations, and appendices which document the theses contained in the text.

To these recommendations I would personally tender one additional: that the Ministry, which has so sagely supported the building of the library of the Laboratoire de Recherches and the study collection of fishes through systematic surveys and publication of results, not only continue but increase support for these worthy projects. The yield of the library and collection are numerous and significant to the public, to science in Québec, Canada, and the world. The recently published *Atlas of North American fresh water fishes* benefited greatly from the completeness of surveys in southern Québec and accurately protraying the distribution of fishes. The spot distribution maps are useful to anglers, fishery managers, ecologists, biogeographers and taxonomists. Perhaps these priceless and irrreplacable collections, together with existing herbaria, insect and other collections, might be gathered and properly housed as a Québec Natural Science Museum. Only recently has society begun to appreciate the many values of natural history collection to education, research and development.

To the authors of *Les salmonidés des eaux de la Plaine de Montréal* I offer my heartiest congratulations. To my fellow anglophone biologists, and naturalists may I suggest they obtain copies, and sit down beside the fireplace, for several evenings of pleasurable and rewarding reading, even if it means periodic reference to a dictionary.

DON E. MCALLISTER

Curator of Fishes, National Museum of Natural Sciences, National Museum of Canada, Ottawa, Ontario K1A 0M8

Birds of Prey of the World

By Friedhelm Weick. 1980. Paul Parey, Hamburg and Berlin, Germany (US distributor IR Unlimited, New York). 159 pp. illus. US$48.

I would not have believed that yet another general book on birds of prey could be of any use to raptor enthusiasts, however Friedhelm Weick manages to write and illustrate as stated by the late Leslie Brown in the foreword, "a much needed guide to identification of all the world's diurnal birds of prey, in the order Falconiformes". However, because the owls are not represented, I believe the title is misleading and would suggest a more apt one, "Falconiformes of the World".

This book written in German and English consists of two sections, the first dealing with an identification key based primarily on size, and the second being 40 colour plates comprising more than 1400 side-view figures painted by the author. Weick has deliberately compressed the text, emphasizing instead his considerable skill as a bird artist. The index with common and scientific names in separate lists at the back of the book facilitates the search for a given species or subspecies.

In my opinion, the first section is of questionable value. The black and white ink drawings, as well as the short descriptions of significant identifiable characteristics, are well-done and useful, but how can one subjectively discern a "very large", a "rather large", or a "large" bird from one another without being able to measure it in the hand? On many occasions in my experience, enthusiastic people have mistaken the "very small" American Kestrel (*Falco sparverius*) for the "medium-sized" Peregrine Falcon (*Falco peregrinus*) just after having seen the latter on television!

The second section, though, is far more useful and certainly unique in its approach. Some minor faults should be mentioned. Due to the large number of subspecies, etc., some of the plates appear crowded, creating some difficulty in attaching labels to each bird correctly. More specifically, in selecting a species with which I am most familiar, the eye colour in *Falco sparverius sparverius*, and perhaps in many of the other falcons, appears somewhat lighter than it should be.

In spite of the above faults, Weick's book will be a source of information on my library shelf to which I will undoubtedly refer to often. Its size obviously restricts its use to other than in the field. I recommend it highly to serious raptor enthusiasts.

DAVID M. BIRD

Macdonald Raptor Research Centre, Macdonald Campus of McGill University, 21,111 Lakeshore Rd., Ste. Anne de Bellevue, Québec H9X 1C0

Behavioral Mechanisms in Ecology

By Douglass H. Morse. 1980. Harvard University Press, Cambridge, Massachusetts. 371 pp., illus. US $25.

It is a common complaint of would-be reformers that both ecology and ethology grew up in the anti-Darwinian atmosphere of the early 20th century, and that, despite the fact that an animal's ecology may be very largely considered a summation of its behaviour, each discipline has tended to ignore both the processes studied by the other and the consequences of its own theories for individual fitness.

The reaction against this has been 'modern natural history' or 'sociobiology,' here 'behavioral ecology', and the hypothesis it has broadly corroborated is that the behaviour of animals is as precisely attuned to their ecology as their morphology is. Most of this advance in the measurement of Darwinian variables has been due not so much to post-Darwinian advances in the technology of measurement, but to a new willingness to spend thousands of hours observing and tallying selectively significant behaviours.

Behavioral Mechanisms in Ecology even-handedly reviews this new discipline, discussing theory and results in the study of foraging, habitat selection, predation, maintenance behaviour, reproduction, competition and sociality. The 1190 references cited are a comprehensive review of the relevant literature up to 1978. The presentation of theory is largely nonmathematical, but only quantitative results are considered. These are presented in an astonishing number of graphs, mostly redrawn from previous publications. There are only 33 illustrations which are pictures of animals (expressively drawn by Jaquin B, Schulz), but 141 figures plot one variable against another. Many of these graphs are both very simple and very large. A third of page 268, for example is taken up by a scatter diagram of three points, and a half of the page by a caption explaining the points. There are, consequently, almost no tables of data.

It is, perhaps, a reflection of the causal importance of natural selection that the data closest to reproductive fitness (reproductive investment and parental roles) seem to fit simple theory most closely, while the behaviours which are most remote from a direct payoff in fitness (foraging strategy) seem to be the most difficult to preduct by theories of simple optimization. Morse traces the influence of these complicating factors. The influence of the danger of predation on behaviour is a recurrent theme, and the volume ends with a call for more research on the hard-to-observe events that are the foundation upon which more visible behaviour is built: the fate of dispersers, predator-prey interactions, and interspecific competition.

This is material which must be understood by any naturalist who aspires to research which goes beyond the enumeration of data for their own sake, and *Behavioral Mechanisms in Ecology* is a very fine introduction to it.

FREDERICK W. SCHUELER

Herpetology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

BOTANY

Guide to Forest Understory Vegetation in Saskatchewan

By W.C. Harris. 1980. Technical Bulletin No. 9, Saskatchewan Department of Tourism and Renewable Resources, Regina. 106 pp. $10.00

This short, non-technical guide will be a useful, colourful accompaniment to the average naturalist, especially in northern Saskatchewan, but also in most other areas of boreal forest vegetation. It is not meant for the serious botanist. Its stated purpose is to aid forestry oriented personnel in assessing site conditions more fully and it will likely be a satisfactory initial training aid. To more fully meet that aim there should have been more emphasis on mosses and liverworts and abbreviations of species names should have been provided for field use. The guide includes a table with number codes describing soil drainage classes as well as a forest cover map of the province, a glossary, an index and several appendices but the actual species descriptions very rarely refer to these parts of the guide and as a result are inefficient. In effect, the guide may be superficially useful to government forestry personnel but it will probably be more useful to the common or garden naturalist.

The plant descriptions (of about 80 species) are given one species to a page with short descriptions under the headings of Growth Habit, Leaves, Flowers, Fruit, and Habitat. This format makes for easy

skimming in absence of a key. The photographs are large and well composed: in most cases two or three photos are given to show temporal stages in the plant or flower's development. Only a few of the photos are of questionable quality, such as those of the two strawberry species. It is unlikely that anyone could differentiate the two just by the photos provided. There are some omissions because of the small number of species shown. For example there are only two lichens shown and only a few mosses, ferns and grasses.

This guide is of sturdy construction with plastic binding, an unusual cover photo and pages which don't stick together when wet. It will fit in one's back pocket and overall it is pleasing to the eye and is clutter-free. These are the main features which recommend it alongside several other books of similar content. Although no acknowledgment is made, the layout of photos and text are almost identical to those in *Wildflowers Across the Prairies* (by Vance, Jowsey and McLean) and in Saskatchewan the two books are complementary in content. It shouldn't take too long for the avid naturalist to digest this book and progress to more specialized works. As a stepping stone, it is a worthwhile guide to most of the common understory plants throughout most of boreal Canada.

JAMES A. ROWSELL

Beak Consultants Limited, 6870 Goreway Drive, Mississauga, Ontario L4V 1L9

Flora of the Prairie Provinces: A Handbook to the Flora of the Provinces of Manitoba, Saskatchewan and Alberta; Part I. — Pteroids, Ferns, Conifers and Woody Dicopsids; Part II. — Digitatae, Dimerae, Liberae; Part III. — Connatae; Part IV. — Monopsida.

By Bernard Boivin. Part I, *Provancheria* No. 2, Universite Laval, Quebec; 1967; 202 pp. $5.00 paper (Reprinted from *Phytologia* vols. 15 & 16). Part II, *Provancheria* No. 3; 1969; 185 pp. $5.00 paper (Reprinted from *Phytologia* vols 16-18). Part III, *Provancheria* No. 4, 1972; 224 pp. $6.00 paper (Reprinted from *Phytologia* vols. 22 & 23). Part IV, *Provancheria* No. 5, 1979; 189 pp. $8.00 paper (Reprinted from *Phytologia* vols. 42 & 43). Set $20.00, available from the author at Herbier Louis-Marie, Universite Laval, Quebec, G1K 7P4, Canada.

With the appearance of Part IV — *The Monopsida*, Boivin's *Flora of the Prairie Provinces* is now complete in taxonomic coverage with the single, but major, exception of the grass family. The latter, along with a general index, bibliography and glossary are now planned by the author as Part V of this Flora series. Perhaps a review of the Flora at this time might be perceived as either long overdue for Parts I-III, or still premature for the whole finished work.

The introduction describes the scope of the work, outlines some evolutionary principles, and explains the author's views on species concepts and key construction. The text-body represents a classical flora with simple dichotomous indented keys to major groups, families, genera and species. For each species, the scientific name is followed by the pertinent synonyms, common names (if any), brief descriptions, indications of phenology (general flowering time), short habitat notes, and much abbreviated geographical ranges. Infraspecific taxa are not separated by keys but treated within the text under each species, along with their own synonyms, habitat, and distribution. Short taxonomic or distributional comments are often included.

This Flora by a foremost Canadian floristic taxonomist constitutes a complete, critical, concise and relatively up-dated treatment of the vascular flora of the Canadian Prairie Provinces. Preparation of the Flora has obviously involved much extensive and painstaking library and herbarium searching, compilation, and synthesis of information by the author. Unusual species reports have been indefatigably traced down to verify or discount them. The resulting work is comprehensive, intellectually stimulating, innovative, and often controversial, and at least indirectly it points up numerous taxonomic difficulties in our flora needing further study. Clearly, from a scholarly point of view, Boivin's Flora must be considered a landmark in Western Canadian floristics.

Nevertheless, several shortcomings or at least distracting elements are perceived in this work. The keys to species are composed of unusually brief leads, mostly employing only a single character. Generally the choice of key characters seems good, with easily observable and decisive ones used, although other apparently useful or even better characters are often omitted, sometimes even from the brief descriptions. Because of their simplicity, the keys are remarkably efficient to use, *but only if* one has excellent plant specimens on hand revealing the required characters. Such is not necessarily nor even usually the case.

Taxonomic judgements of how narrowly or broadly species are interpreted (i.e. — "splitting" vs. "lumping") must be considered privileged — not a matter of correctness or incorrectness per se. Boivin has explained his philosophy of species delimitation in the introduction and has reiterated or amplified this at

various places elsewhere in the text. With some notable exceptions, he has followed his stated concept in practice. In my opinion, Boivin's species' circumscriptions for the most part tend overly conservative (i.e. — too broadly inclusive), with the apparent result that various taxonomic problems and the distinctions between similar but I think often meaningful species or variants have been obscured by sweeping them under a carpet of synonomy. The tongue-in-cheek accusation sometimes made that angiosperm taxonomists accept species differences no smaller than the 10× level of mignification, seems extended by the author to almost the "eyeball-level"! I also think that too many major taxonomic reinterpretations and associated nomenclatoral changes have been made by the author with less than satisfactory explanations. One is thus inclined to accept any such changes only tentatively, if at all, until substantiated by other authorities.

This Flora seems to represent primarily a herbarium compilation, with field characteristics understressed and habitat information sometimes lacking precision. The taxonomic conclusions and various habitat/distributional notes suggest that the author has in all likelihood acquired his knowledge of the flora of Western Canada mainly through available herbarium specimens rather than from extensive field experience here.

An inconvenience to most users of Boivin's Flora will be his unfamiliar sequence of families, necessitating a frequent checking of the separate indices of each booklet. Instead of accepting the conventional and familiar Englerian System, as have most flora-manuals, or the modern phylogenetic systems of Cronquist or Takhtajan, as have a few recent manuals, Boivin has basically followed the Hutchinson System with its major separation of the dicotyledonous angiosperms into primarily woody and herbaceous families. The General Index planned for Part V will be welcomed.

Technical botanical terminology is used throughout. Some frequent terms are ones seldom encountered elsewhere, even in other technical works (e.g. — isomegueth, dimegueth, tegule). A glossary is promised in Part V. At least initially disconcerting to some English readers may be the frequent usage of several unfamiliar French terms, especially for topographic features (e.g. — "Boise Coteau", for the Cypress Hills, Wood Mountain, and adjacent plateaus; "Coteau de Prairie" for the Manitoba Escarpment; "La Petite Montagne de Cypres" for the Sandilands Uplands in south-eastern Manitoba). Common names are not of great concern to most professional taxonomic botanists since these lack standardization, but I think they do represent an important link with amateur botanists. In Boivin's Flora this professional-to-amateur link is much weakened by the fact that such a large percentage — I would estimate about half — of the common names given by the author are not those in common usage and familiar to Western Canadians.

In this day of expensive flora-manuals, the low price of Dr. Boivin's *Flora of the Prairie Provinces* appears to be a remarkable bargain. At least some of this cost economy, however, seems achieved at a rather serious sacrifice in the technical quality and visual attractiveness of the published product. The booklets have been economically reproduced by a reductive photographic offset method directly from the original typescript. The work suffers from the usual technical deficiencies of such production methods. In addition, the original typescript appears to have lacked careful typing, editing and proof-reading.

The eye-disturbing, but really inconsequential, non-capitalization of proper adjectives (e.g. — canadian, europaean, linnaean) throughout the text seems too consistent to be blamed on typographical errors. The soft-paper covers and bindings of the booklets are hardly of high or lasting quality, although the stapling at least adequately maintains the booklet integrity. Clearly the value of this publication is in its informational content rather than its form. But the quality of the former, and its importance as a scholarly contribution to North American botany, surely deserved a better product packaging. I find it surprising that this important Flora would not have been subsidized or produced as an official publication of the Canada Department of Agriculture.

The afore-mentioned deficiencies, I fear, will likely reduce the popular appeal and utility of this Flora for undergraduate students, non-taxonomic botanists, amateur plant enthusiasts, general naturalists and other lay-persons, contrary to the stated goals in the Preface. It does not represent a particularly practical guide to be used singularly for plant identification, but rather seems best used in combination with other flora-manuals. But the possible utilitarian lack for non-professional users does not detract at all from the high scholarly value of this publication series as an indispensable reference source for systematic botanists studying the flora of this region and elsewhere in North America. I would strongly recommend that no important plant taxonomic library should be without this Flora.

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Living with plants: a guide to practical botany

By Donna N. Schumann. 1980. Mad River Press, Eureka, California, xx + 328 pp., illus. US $14.50.

If ever you've felt the frustration of not knowing why you are doing what to whom in the garden, *Living With Plants* could solve your problem. Donna Schumann has done an admirable job of bridging the gap between pure botanical science and the strictly practical side of horticulture.

The book was written for use in the author's course in gardening, and thus it covers all popular aspects of the topic. The reader is immediately introduced to a plant, complete with reams of new vocabulary through which to wade. It is easy to see why botany is often referred to as the science of inventing new words. Professor Schumann valiantly tries to make this necessary chapter as painless as possible through the use of profuse, clear and well-labelled drawings, some of a rather less conventional nature. (My favourite is the marriage of Miss Glucose and Mr. Fructose to produce Mr. and Mrs. Sucrose as an aid to understanding enzymes). However, once digested, the author moves on to more familiar ground. Armed with this introduction, the readers are equipped to understand why they use rooting hormone, how pest control is really supposed to work and why poinsettias need darkness to bloom, along with a host of other quandries that often plague the curious gardener.

Although the book does answer a lot of horticultural whys, it functions mainly as a manual of horticultural practices. Instructions for all basic gardening chores are given clearly and are almost always accompanied by good illustrations. There are lots of charts of plants the author recommends for special purposes, as well as useful charts on comparative herbicides and pesticides. Since *Living with Plants* is an American publication, the trade names in the latter charts to not always apply here. However, the chemical names are universal and a great help when deciding among the profusion of products available on the nursery shelf. It is interesting to note that most of the Organochlorine pesticides, the group to which DDT belongs, have been banned or use-restricted in the U.S., whereas they are widely available in Canada. This section on 'Meeting the Enemy' is especially modern as the author tries to integrate discussion of chemical warfare and organic controls to overcome garden pests. Most gardeners are not ambitious enough to expend the greater effort required to use organic gardening techniques and too often fall back on the simpler but more dangerous chemicals. Mrs. Schumann tries to strike a medium between both approaches, discouraging the indiscriminate use of chemicals.

Most of the maps used in the book generally do not extend beyond the American border, and many of the plants listed are only found in southern climates. However, with care and a little imagination, the maps and plant lists can be interpreted for use in southern Canada.

As a whole, the book is well written and a useful reference tool for gardeners. What makes it unique is its ability to explain in relatively simple terms why a procedure works so that the gardener can truly understand why he or she is using a specific product, technique or tool. (Also why Grampa's advice about pruning was right!) In the long run this knowledge can be used to help the individual intelligently adapt techniques to his or her unique requirements, rather than be left to slavishly follow mysterious recipes, making the whole experience of gardening that much more exciting and satisfying.

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Common and Botanical Names of Weeds in Canada/ Noms Populaires et Scientifiques des Plantes Nuisibles du Canada

By Jack F. Alex, Richard Cayouette and Gerald A. Mulligan. 1980. Agriculture Canada, Publication 1397 (Revised). Supply and Services Canada, Hull. 132 pp. $5.75 in Canada; $6.90 elsewhere.

This publication is an integration of *Common and Botanical Names of Weeds in Canada* (Canada Weed Committee 1969) and *Noms des mauvaises herbes du Québec* (latest edition, Ferron and Cayoutte 1975). With one exception, the rules for spelling English common names, the book is completely bilingual, with English and French parallel columns on each page.

The bulk of the material is presented in four large tables. In Table 1, the entries are arranged alphabetically by botanical (Latin) name. The family name, one common name in English, one common name in French and a four-digit code number assigned by the Expert Committee on Weeds (formerly the Canada Weed Committee) are given for each species. Tables 2 and 3 present the same information, except for family

name, arranged alphabetically by English and French common name respectively. Table 4 gives the botanical names arranged in numerical order of their code numbers.

More than 900 species have been designated as weeds by the authors. In addition, several species have been divided into their most important varieties (e.g. *Rhus radicans* is given as 1546 — *R. radicans* L. var. *negundo* — poison-ivy; 1960 — var. *radicans* — eastern poison ivy; and 1961 var. *rydbergii* — Rydberg's poison-ivy). Many readers of the Canadian Field-Naturalist may be surprised to find that species such as *Acer saccharum* — sugar maple, *Arisaema atrorubens* — Jack-in-the-pulpit, and *Ulmus americana* — American elm are listed as weeds. Similarly, agriculturalists might ask why alfalfa, orchard grass, red clover, white clover, oats and barley are included in the list. The authors explain that "many plants that are regularly or occasionally cultivated for crop, ornamental or other use may reappear at some other time or place as unwanted plants. Such plants are weeds in the sense that they are growing where someone does not want them, and have been included here."

A few species that are considered weeds by some people in Canada are not included. In southwestern Ontario some farmers have dense infestations of bur cucumber (*Sicyos angulatus* L.) in their fields. None of the various species of forget-me-not (*Myosotis* L.) are listed but some gardeners claim that these plants constitute a serious weed problem. *Lonicera tatarica* L. is included but *L. japonica* Thunb. is not; several botanists claim that the latter is more of a weed than the former.

Despite the above comments, this book does list the vast majority of plants that are weedy in Canada. Many weeds of local distribution in Canada such as smooth pigweed (*Amaranthus hybridus* L.) are listed as well as the obvious widespread species such as wild oats (*Avena fatua* L).

In general, there is only one English name and one French name recognized for each species. However, if a second English common name is in fairly widespread use throughout part of Canada it may be listed in Table 2 with the direction "see/voir" the accepted common name. For example, couchgrass is in Table 2 followed by "see/voir grass, quack". Also, "creeping Charlie see/voir ground-ivy." Only with the accepted common name do you get the code number, botanical name and French name. In Tables 1, 2 and 3, there is only one French name for each species. There are a few weed species that do not occur in French-speaking areas of Canada and for which there was no acceptable French common name (e.g. *Cenchrus longispinus* (Hack.) Fern. — long-spined sandbur). These species are left without a French name.

What is the purpose of publishing this book and who will use it? The authors point out in their introduction that "the common, or vernacular, name (of a particular Canadian weed) often differs from one region to another." Further, they note that there are "variations in the form and spelling of weed names in Canada and in foreign literature". All of this variation can cause confusion for farmers or gardeners who wish to control a particular weed, but through using the wrong name for the plant, spray it with a herbicide to which it is resistant. Advisors and agricultural representatives must also know exactly which weeds are growing in a given field. There is increasing evidence that many closely related species which are very similar in appearance can differ in such critical aspects as response to herbicides, kind and amount of dormancy, pattern of seedling emergence, and ability to perennate.

As the formulation and testing of herbicides has become more exact the scientists involved with this area of research have come to realize that errors can arise because a herbicide that is recommended for the control of one plant species has been sprayed on a similar-appearing but quite different species. Part of the problem obviously lies with errors in identification but further complications arise when a single common name is used for different species. This book will be of great assistance in correcting the latter problem.

The main purpose of assigning code numbers to each species or taxon is to enable the "Expert Committee on Weeds" to implement computerization for the publication of its annual Research Reports and Abstracts. Code numbers beginning with the numeral 1 refer to weeds *per se*, while those beginning with 9 refer to crops as weeds. This sytem will undoubtedly prove useful in the future for many other purposes such as the production of distribution maps, the listing of various parasites and predators, etc. It would be possible to extend this code number system to all Canadian plant taxa and this could lead to many additional uses for the system.

However, there are drawbacks to using a system of code numbers. An obvious problem is illustrated by the three varieties of poison-ivy mentioned earlier in this review. When a new species is added to the list or the name of a species is changed, the code numbers cannot always be adjusted to accommodate this change. Thus, within a single species such as poison-ivy you can have two quite different code numbers. A simple letter code using the first six letters of the botanical name might ultimately be more useful.

The book is produced attractively. It features large clear type and a coloured picture of a most important toxic weed, tansy ragwort (*Senecio jacobaea* L.) on the cover. At 28 × 21 cm in dimensions and with 132 pages, it is too large to be handy in the field, but

undoubtedly its major use will be as a reference book in offices across the country. It has proved to be a well-thumbed, frequently-consulted text in our laboratory.

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ENVIRONMENT

Extinction: The Causes and Consequences of the Disappearance of Species

By Paul and Anne Ehrlich. 1981. Random-House, 304 pp. US$21.00

Rare Birds' Nest Stolen! Sperm Whales Protected! Falcons Fly Again!

Recently, animals threatened with extinction are getting a lot of press coverage. The escalating extinction rate of wildlife species, where wildlife means all wild animals and plants, is becoming an issue of global concern. The World Conservation Strategy, a blueprint for global conservation of natural resources, includes the preservation of genetic diversity as one of the Strategy's three principle goals. The eminent socio-biologist Dr. E.O. Wilson considers the continuing extinction of wildlife species the greatest catastrophe of our times because the future of mankind becomes more constrained with each extinction.

A new book, *Extinction*, by Paul and Anne Ehrlich (authors of *The Population Bomb* and *The End of Afluence*), looks at this subject in considerable depth. In doing so, the Ehrlich's develop an excellent analogy: the authors see each extinct wildlife species as a rivet popped from Spaceship Earth. Although the ship will withstand a few missing rivets, the cumulative effect will be disasterous.

As professional biologists, the Ehrlich's have considerable expertise with wildlife. They present a comprehensive look at the importance of wildlife, the ways in which wildlife species have been and are being pushed to extinction, and the potential remedies to this "rivet popping". Throughout, interesting insights are made into "the extinction factors". Of particular interest is a section on prehistoric extinctions. It is hard to imagine the anger of future generations deprived through the loss of some present wildlife species. A discussion of species deprived *us* by our earliest and more recent ancestors allows us to feel some real anger.

A second insight is into the central role of habitat conservation in the fight to keep wildlife species thriving. The single species approach to conservation (the tiger, the rhino, the panda), although very successful, has to give way to a broader thrust directed at habitats. This is especially true of the Tropical Rain Forests which, although covering only 6% of the earth's surface, contain nearly 50% of wildlife species. These forests are disappearing at an incredible rate (conservatively estimated at 50 acres per minute). This short-sighted destruction of tropical forests spawns another analogy: trees are terrestrial whales.

The book is exhaustive, providing all the basic information about wildlife extinctions. The book breaks each large area into many small sections. The notes to each chapter are extremely complete, providing tonnes of additional reading for the keeners. This comprehensive approach leads to the stacking of detail on detail like cord wood making the book hard to read at times. At its worst, it reads like a pneumatic drill sounds. Such is the danger inherent in carefully outlining the direct economic benefits of plants to mankind, or the nefarious ways *Homo sapiens* exterminates wildlife — directly and indirectly.

To the concerned, the book provides the vivid background to a biological crisis. To the converted, little of this book is new. The solutions proposed are familiar friends: stabilizing world population, founding a new economic order, replacing short-term gain with longterm benefits. In the end, after considerable discussion of the need for habitat preservation and a new thrust, the Ehrlich's conclude:

> "What may be needed now is a great act of leadership. Just as President Kennedy put the U.S. on the road to space, another president could put the nation — and, one would hope, the world — on a road to treating the Earth as a Spaceship".

Extinction expertly details an old but escalating problem. What we need now is action on a grand scale. *The World Conservation Strategy* suggests a number of concrete solutions. The World Wildlife Fund's coming campaign on The Tropical Rain Forests is also an encouraging sign. In short, the time for thinking and theorizing is over. We know what to do. Let's do it. Now.

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Natural Resource Conservation: an ecological approach

By Oliver S. Owen. 1980. 3rd edition, MacMillan, New York. 883 pp., illus. US$19.95

The last few decades have seen a public environmental awakening. One result has been many new university courses. It is ecological dogma that when an unexploited resource exists, an organism will evolve to fill that niche. The plethora of textbooks aimed at "ecology and man" or "resource management" courses seems consistent with this. It is inevitable that many of these books will be less than adequate. Faced with a continuing inflow of such books from publishing houses, I have set down a list of three criteria which, in my opinion, all such books should meet.

(1) *Ecology as a science*. All such textbooks should first acquaint students with the basic concepts of ecology. Little is to be gained by introducing complex ecological problems until the student first understands basic concepts such as energy flow, nutrient cycles, population dynamics, ecological succession, biomes, etc.

(2) *Ecology and resource management* should then be covered. Students can learn that ecological principles can show us how to scientifically evaluate problems and then systematically design methods to solve them.

(3) *In depth treatment*. Since the foregoing would tend to give students a superficial view of many areas, occasional in depth treatment is necessary. In depth treatment would enable students to examine at least a few problems to see the different perspectives and complex interactions that face any problem solving institution or committee.

It is particularly important that a text on ecology and man be well written. Many engineers, general arts students and landscape architects, for example, may get their one and only introduction to ecology through such a text. Poor understanding of basic concepts may have severe economic, ecological or political repercussions in years to come.

Owen introduces basic ecological principles in one chapter, 34 pages. It might be argued that a scanty 34 pages were necessitated by space limitation, but the book is more than 800 pages long.

Resource management problems discussed include soil erosion, pollution, forestry, wildlife, pesticides and energy. However, the treatment of these problems is uneven. The chapter on wildlife begins with a general discussion of the problem of extinction. Yet, of 76 pages on wildlife, 34 are devoted solely to the production of a few species of animals for North American sportsmen to shoot. If there was insufficient space to deal with the ecological factors regulating species diversity, destruction of tropical rain forest and coral reefs, the fate of African game reserves, etc., surely it could have been gained by: (1) reducing emphasis on intensive management of a few game species, or (2) by eliminating the excessive use of photos of dead ducks, deer, and fish.

Moreover, there is a lengthy discussion of the infamous Kaibab deer herd, which Owen calls "classic example of a deer irruption" and graphically describes how . . . "deer now began to succumb to slow, agonizing death by starvation. Within the six-year period from 1924-1930, 80,000 deer starved, their gaunt emaciated carcasses bearing eloquent testimony. . . ." Yet, 10 years ago, Caughley (1970) demonstrated that the Kaibab example was at best careless science, at worst, outright fiction! It is thoroughly discussed in Colinvaux's (1973) text. It is inexcusable that ten years and two printings later Owen is still repeating the Kaibab story, complete with a redrawn figure and completely imaginary data points neatly labelled!

This leads directly to the third criterion: illustrating the complexity of ecological problems. Let me cite three of many possible examples. First consider food production. Owen starts soil management with the title "Need for Greater Food Production by American Farmers" and states that the United States "must export food to help prevent massive starvation". There is no mention of alternate viewpoints such as Lappé and Collins (1977) who present a convincing case that world starvation is largely a result of inequitable land ownership in developing countries, and the growing of export crops (coffee, tea, sugar cane) instead of food. Thus, at present, starvation may be as much a political problem as an agricultural one. Second, consider energy. The concept of energy quality (Lovins 1977) is essential for a scientific perspective of energy demand. For example, roughly half of all usable energy consumed in Canada is used simply to produce low grade heat (less than 140° C) (Crow *et al.*, 1978). Yet, Owens does not introduce the reader to energy quality. Neither is Lovins' (1977) proposed "soft energy path" presented as a distinct alternative to the "hard energy path" we have taken the last few decades. Third, consider fisheries. Owen adds three paragraphs entitled "Dam versus Darter: a Classic Confrontation" in reference to the controversy over the Tellico Dam and the Snail Darter. This overly-simplistic analysis ignores the fact that there were many other economic and environmental reasons for scrapping the Tellico Dam (Ballal, 1977).

The fact that this book is in its third edition suggests that it has its redeeming points — and indeed it has. For example, it provides a wealth of practical examples that are directly relevant to American students, and many of the figures and photographs visually

emphasize concepts that are presented in the text. But it is no longer enough to add a few new paragraphs to an old text. It is remarkable to think how much one additional decade of work has changed our perspectives on planetary survival.

I rate the text a minimal pass on my first criterion, and a failure on the next two. Better texts are now available, and instructors and students would do well to consult them.

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MISCELLANEOUS

Hawk Lady: the story of a woman who opened her home to care for wild birds of prey

By Stellanie Ure. 1980. Doubleday and Company, Toronto, 215 pp., illus. $14.95

The "hawk lady" of the title, Stellanie Ure, has recorded her experiences in caring for and rehabilitating injured, sick and orphaned raptors of 26 species. She and her family have been instrumental in returning many of their patients to the wild, and she imparts much information on the behavior, feeding, etc., of the many hawks and owls she treated. She is to be commended for her efforts in assisting these threatened birds. Unfortunately, the book seems overly long and detailed, and failed to sustain my interest. I feel it would be a real value only to those actively involved in similar endeavours.

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Completely Foxed

By Miles Smeeton. 1980. Van Nostrand Reinhold. Toronto. xi + 148 pp., illus. $9.95.

After he retired from the British army in 1946, Miles Smeeton and his wife Beryl moved to Canada, later sailed around the world, and finally settled down on what has become a private game sanctuary in the foothills of the Rocky Mountains near Calgary, Alberta. Their aim was to do what they could to help native endangered species; this is the story of their efforts on behalf not only of the Swift Fox as the title of the book suggests, but also the Trumpeter Swan, the Wood Bison, and various other animals, especially the Moose.

The publisher calls this a joyous book, but such an adjective glosses over the hard work and often heartache which accompany living day by day with and for wild animals. An example was the care of Zeus and Io, two pinioned Trumpeter Swans which the Smeetons obtained with great effort from the government and hoped to breed so that their progeny would return to the wild. These birds lived happily in summer on the sanctuary pond, but in winter when the water froze over they were at the mercy of any passing lynx or coyote. The Smeetons thus erected a wind and motor-driven propeller which would theoretically continually stir up the water and keep it from freezing. This was successful only until the weather turned really cold. Then someone had to break up the newly-formed ice by hand each morning, hauling it to the edge of the pool and piling it high. Since this task took up to two hours a day, some other solution had to be found. The next plan was to build a geodetic dome of wood and fabric over the water to make the swans an indoor swimming bath. This worked well until spring, when the 600-lb dome had to be removed before the ice melted and it sank from sight. At first the Smeetons tried to raise and shift it with the help of a hot-air balloon, a job which was beyond them and sent sev-

eral helpers to hospital. Finally, with friends, they managed to carry it to shore.

The following winter the well near the swan's pond went dry because of drought, so the Smeetons were forced each day to siphon into the pool about five 45-gallon drums of water brought from the house. They only gave up their efforts on behalf of the swans when they were informed by government that no birds raised in captivity could be released to the wild (the whole point of their labors) and that they must pay for a licence for the pleasure of keeping their swans. They reluctantly turned over Zeus and Io to the Saskatoon Zoo.

Other chapters in this book are devoted to the antics of the Swift Foxes Emma, Napoleon, Josephine, Nelson, and their progeny; to the Wood Bison Martha and Mary who likes to sneak indoors to lick the butter on the dining room table; and to various Moose who feed from Beryl Smeeton's hands. Those who like to read about such an animal wonderland will enjoy both the text and the lovely photographs.

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Evolution for Naturalists: the simple principles and complex reality.

By Philip. J. Darlington, Jr. 1980. Wiley, Toronto, xvi + 262 pp., illus. US $19.95.

This book should be used by both serious amateur naturalists and advanced professional biologists . By reading this book serious naturalists will obtain a "self-education" in evolution while professional biologists will obtain a fresh reorientation of evolutionary theory. Since Darlington argues about several profound aspects of evolutionary theory, serious amateur naturalists who wish to make intelligent decisions about evolution will have to work and think while reading much of this text. Professional biologists may feel the text is too verbose until one of Darlington's innovative, unconventional ideas causes a re-reading of sections and careful thinking. The text is replete in many areas with very "simple principles" that everybody understands while in others are "complex realities" upon which professional biologists have yet to agree. Therefore, the subtitle of this book perhaps describes this text best.

Darlington verbally separates naturalists from professional biologists throughout his book but he has done an inadequate job trying to create such a dichotomy. Many areas of the text are clearly written for uninformed naturalists while others are much too involved for such persons. Steming from his objective to write for uninformed persons by using little terminology, grammatical errors and clumsy phrases become numerous.

Darlington feels that there have been many evolutionary principles uncritically accepted with bias and therefore many theories are most likely wrong. He provides many reassessments of evolutionary thoughts not available in other texts. An excellent discussion is provided on the Darwinian revolution (chapter 1). The small print on page 5 should be carefully read by all persons interested in evolution because each will be awakened to the fact that a perfected theory of natural selection was published by a Patrick Matthew in an obscure journal before Darwin first boarded the *Beagle*. Kin and group selection are put into contexts totally unfamiliar to both amateur naturalists and professional biologists. Good arguments are provided concerning population-wide reciprocal altruism inhibiting kin-limited altruism. The primacy of the chicken/egg hypothesis is nicely discussed. Darlington sees natural selection as the "selective elimination of individuals that walk in the wrong directions". He feels that competitive exclusion is the result of convenience since the choice for or against coexistence is facultative. Another idea is "Genes that promote evolution . . . by reducing their own stability actually promote their own survival." An informative chapter (9) on human evolution is perhaps the best in the book. Darlington consistently provides good reasons for deploring the oversimplified approach used in many scientific journals purporting to construct mathematical models of evolution.

Typographical errors are scarce and the text reads with facility. A "reading and reference" list at the end of each chapter cites literature by subject and an excellent index appears. University professors should find this text the best newer book available for evolutionary seminars and discussion groups held with both undergraduate and graduate students. One's speculative power will greatly increase after reading this book.

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British Natural History Books, 1495–1900: A Handlist

By R. B. Freeman. 1980. Dawson (Distributed by Shoe String Press, Hamden, Connecticut). 437 pp. US $29.50.

In this volume the author has brought together 4206 titles of books published in a period of just over three centuries, ending in 1900. These titles include books about the flora and fauna of the British Islands, including Ireland, the Channel Islands and Heligoland. Also included are general natural history books written by the inhabitants of these islands, as well as translations into English of relevant books by foreign authors, plus a few American books which have appeared in British editions.

The book is divided into four sections: a short introduction which outlines the scope, problems involved, methods of citation, inclusion of various editions, etc.; the main alphabetical listing of titles, with dates and places of publication and publisher, where known, each entry being numbered sequentially; a list of titles in date order from 1495 to 1900; and a subject index which has been derived mainly from information given in the titles.

It is impossible to assess the completeness of a work such as this, especially from this continent, but there is no question that the author has delved deeply into the early natural history literature of the British Isles. The book will be of considerable use to anyone who needs to search out an old title or who wishes to trace out the early natural history of these islands.

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ISSN 0008-3550

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